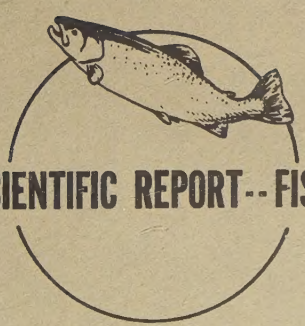
CENTRAL NORTH PACIFIC ALBACORE SURVEYS JANUARY 1954 - FEBRUARY 1955



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UNITED STATES DEPARTMENT OF THE INTERIOR
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Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating Agencies and in processed form for economy and to avoid delay in publication.

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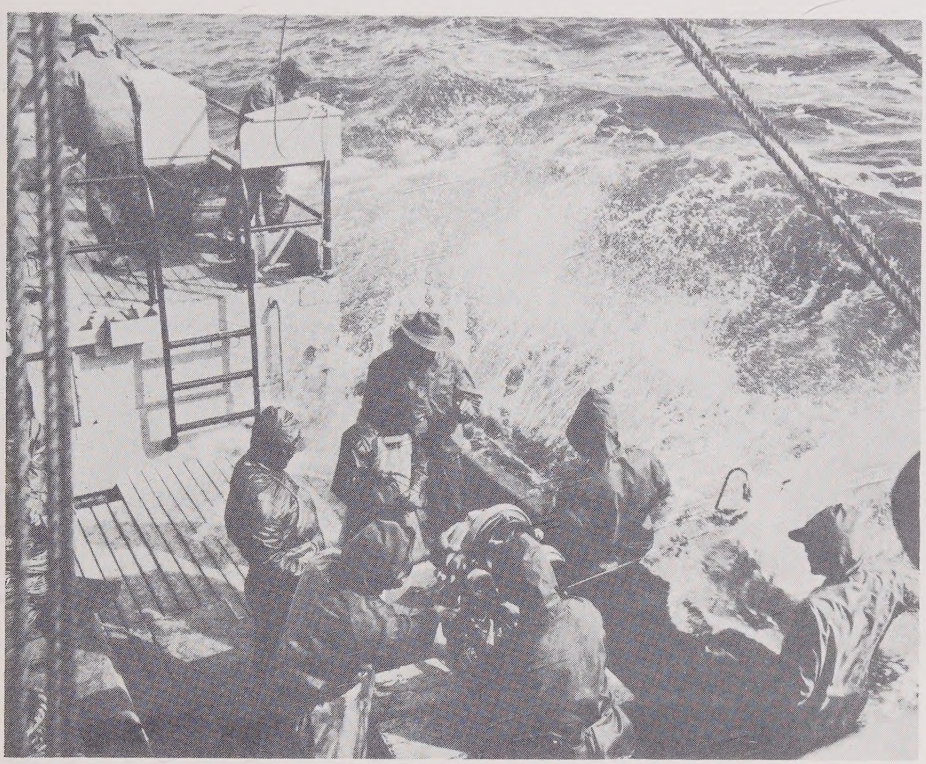

CENTRAL NORTH PACIFIC ALBACORE SURVEYS, JANUARY 1954 - FEBRUARY 1955

By

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Honolulu, T. H.

Special Scientific Report--Fisheries No. 173

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ABSTRACT

This report embodies the fishing results from seven exploratory cruises in the North Pacific during the one fall and two winter seasons between January 1954 and February 1955. These results are supplemented by Japanese commercial longline catch data for the same peri

Albacore, Germo alalunga (Bonnaterre), were caught during all three seasons on longl and were taken by trolling only during the fall and second winter. The longline-caught albacor covered a wider size range than did the troll-caught fish.

There appears to be a parallel north-south shift with the seasons of the albacore popula and the transition zone between the North Pacific Current and the Aleutian Current. During th winter both were located south of their fall positions.

Also included in this report are discussions of the vertical distribution, sex compositic and tagging of albacore as well as data on the miscellaneous species of fish taken.

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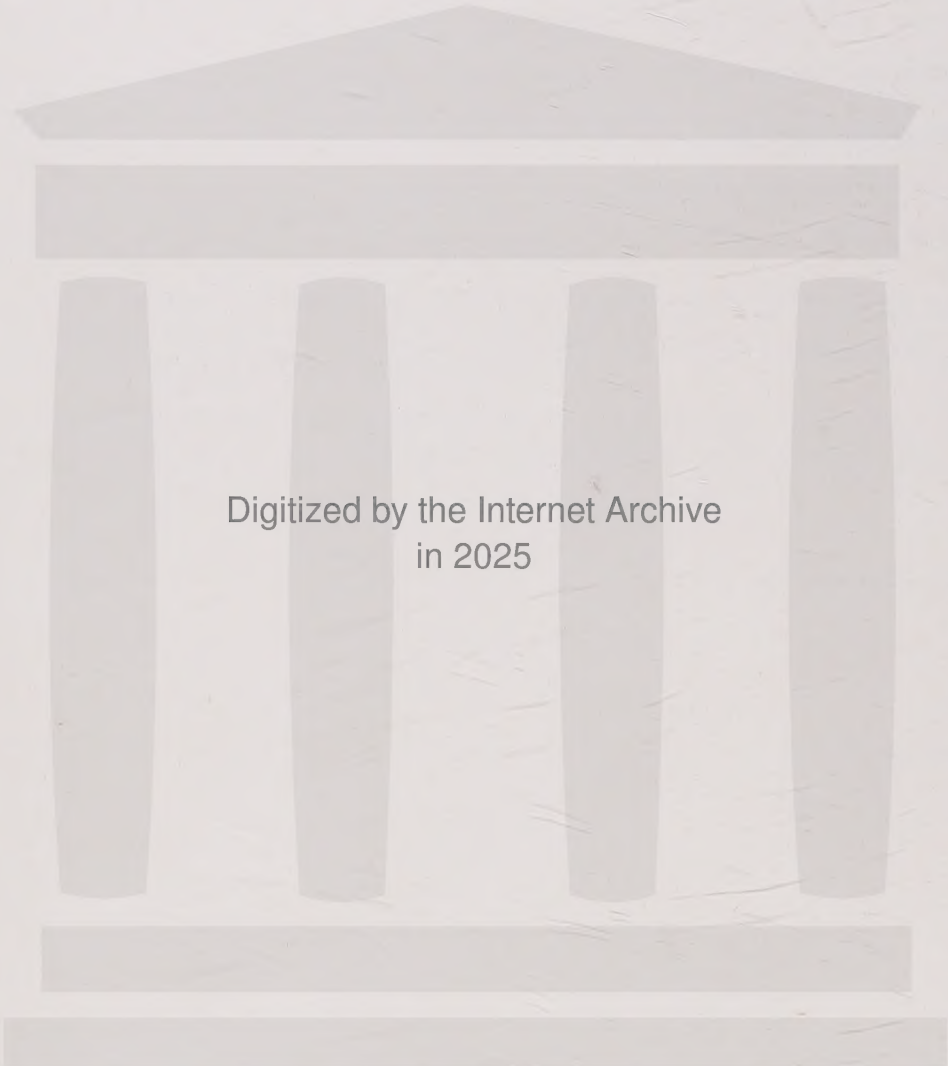
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This is the first in a projected series of rts by the Pacific Oceanic Fishery Investi- ons (POFI) on the distribution of albacore, mo alalunga (Bonnaterre), in the Pacific h of Hawaii. Financial support for the ies was provided under the Saltonstall- nedy Act (Public Law 466-83rd Congress).

Albacore are widely distributed in the ical and temperate Pacific. They are taken longline gear along with yellowfin tuna in central and western equatorial waters rphy and Shomura 1953b, Murphy and Otsu) and support commercial fisheries in the th Temperate Zone. During the summer early fall, albacore are taken in commer- quantities by trolling and live-bait fishing he west coast of North America from south- Baja California as far north as British mbia (Clemens 1955). In addition, there the Japanese fisheries--a pole-and-line ry operating off the coast of Japan during arly summer and early winter and a winter ine fishery in the area from Japan east to ay Island (Suda 1954).

The present paper reports the results of fishing cruises of the John R. Manning and cidental catches of four hydrographic cruis- the Hugh M. Smith and the Charles H. rt over the period January 1954 to February (table 1). Also incorporated are the catches ortion of the Japanese albacore fleet that ated in the same or contiguous areas during rvey. The California Department of Fish Game participated in the first series of alba- cruises (January-March 1954, table 1), sur- ng west to 140°W. longitude; their results be published elsewhere.

Through this and subsequent reports we will use the vernacular names of the fishes. These, with their commonly accepted scientific names, are listed in the Appendix as Table 23.

ACKNOWLEDGMENTS

We are indebted to fellow staff members and officers and crew members of the vessels for their part in carrying out the field work. We would especially like to thank Mr. Toshizo Nomura of the Kanagawa Prefecture Fisheries Experiment Station for making available Japanese catch records. The vertical and surface temperature contours were prepared by Mr. T. S. Austin and the writers. Mr. Richard N. Uchida assisted in summarizing the data and Mr. Tamotsu Nakata drew the figures.

DESCRIPTION OF FISHING GEAR AND OPERATIONAL METHODS

Two types of fishing, longlining and trolling, were used to sample the North Pacific albacore. The longline method of subsurface fishing was developed by Japanese fishermen. Shapiro (1950) gives an excellent discussion of the history of the gear, and Shimada (1951) gives details on its construction. The gear used for this survey was essentially the same as that described by Mann (1955). A set consisted of about 60 "baskets" or skates of gear joined end on end, with 13 hooks on each basket (fig. 1). One half of the gear was set with 5-fathom floatlines and the other with 15-fathom floatlines. Frozen sardine and herring were used for bait on all three longline fishing cruises. The gear was set at daybreak in a little over an hour. Hauling commenced at

ble 1.--Operational data on POFI cruises in the North Pacific, January 1954-February 1955

essel	Cruise	Period of operation	General area covered		Type of operation
. Manning	19	Jan.-Mar. 1954	22°-36°N.	145°W.-160°W.	Longline, trolling
. Smith	25	Jan.-Mar. 1954	22°-40°N.	140°W.-165°W.	Hydrographic, trolling
. Manning	22	Sept.-Nov. 1954	22°-47°N.	159°W.-177°W.	Longline, trolling
. Gilbert	17	Sept.-Nov. 1954	22°-45°N.	160°W.-171°E.	Hydrographic, trolling
. Manning	23	Dec. 1954-Feb. 1955	22°-37°N.	157°W.-180°	Longline, trolling
. Gilbert	18	Dec. 1954	22°-40°N.	157°W.-162°W.	Hydrographic, trolling
. Smith	27	Jan.-Feb. 1955	22°-37°N.	158°W.-170°E.	Hydrographic, trolling

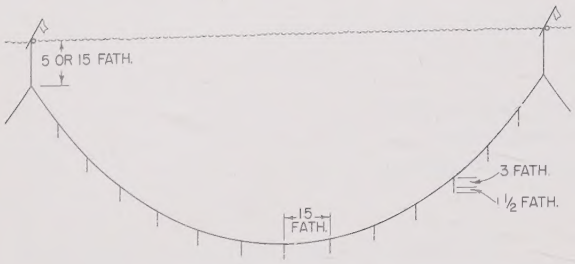

Figure 1.--Schematic view of one basket of the longline gear used in albacore fishing by POFI vessels.

noon and was done in the reverse order of setting. The hauling time varied from station to station depending on the number of baskets fished and on the prevailing weather conditions (tables 14 to 16, Appendix) but usually took about 4 hours.

Three types of trolling--incidental surface, deliberate surface, and experimental deep trolling--were used to sample the albacore in this survey. Incidental surface trolling was done at a vessel speed of about 8 knots on the hydrographic and fishing cruises during all daylight runs between stations. Two to five lines were fished, with a boom rigged out amidships when more than three lines were used. The trolling lines, of No. 261 hard-laid cotton line, trailed from 15 to 25 fathoms beyond the stern. The inboard end of the line was secured to a shock-absorber made of a pair of galvanized steel springs 12 inches long and 1-1/2 inches in outside diameter. The outboard end of the line was joined by a swivel to 1-1/2 fathoms of No. 18 stainless steel wire leader. During the course of each cruise, a variety of lures were used. These included red, white, and amber-colored plastic jigs and feather jigs with plastic or lead heads. Several combinations of white, red, green, and brown feathers were used.

Deliberate surface trolling with five lines (three from the stern and two from the trolling boom) was done at each longline fishing station for 2 hours along the "soaking" line. The makeup of the trolling gear was exactly as described for incidental trolling, but the vessel was slowed to 6 - 6-1/2 knots.

Deep trolling at a vessel speed of 3 to 5 knots was tried at seven longline stations on Manning cruise 23 (December 1954-February 1955). The gear had four 10-fathom branch lines (261 cotton line with 1-1/2 fathoms of No. 18 wire leader) spaced at 15-fathom intervals on a mainline of 5/32-inch cable. The mainline was weighted with either a 50-pound sem depressor or a "kite-type" depressor. Both feather lures and fresh frozen sardine were used as bait, the latter being secured to the hook with linen twine.

WEATHER

The success of fishing depends to a certain extent on the prevailing weather conditions. Longlining becomes hazardous and therefore is generally not attempted in very rough seas or when the winds reach 20 to 30 knots. During the three longline cruises storms were encountered which interrupted fishing for 1 to 7 days at a time, and of a total of 91 days spent north of 30°N. latitude, 39 days (43 percent) were considered too rough for longlining (table 2).

ALBACORE

Distribution and Abundance

Longline Catches. A total of 52 longline stations were fished during the three cruises. Albacore were taken at 20 stations but the catch on any one station was generally small (tables 11 to 13, Appendix). A notable exception was a catch of 42 albacore at station 8 (33°58'N., 159°44'W.) on Manning cruise 19.

Two things are apparent from the albacore catch distribution (fig. 2). First, the northern limit of the albacore distribution was not defined because a combination of adverse

Table 2.--Summary of weather conditions encountered on POFI cruises north of 30°N. latitude

Cruise	Total number of days spent north of 30°N.	Good weather		Rough weather (seas >5, winds over 20 kt.)
		Number of days fished	Days spent traveling	
Manning 19	25	12	1	12
Manning 22	41	14	9	18
Manning 23	25	15	1	9
Total	91	41	11	39

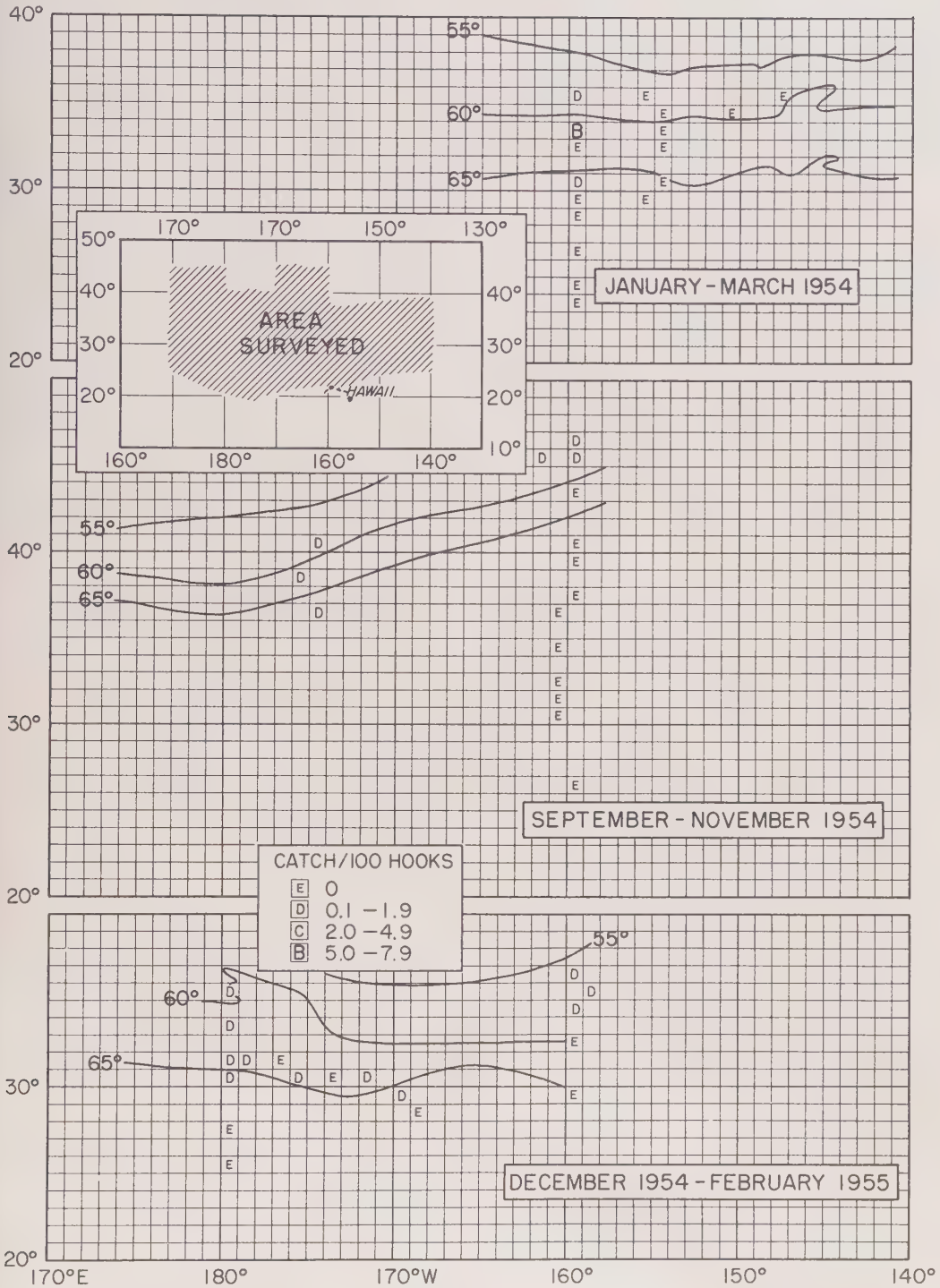

Figure 2.--Summary of POFI longline albacore catches in the North Pacific.

weather and logistic limitations made fishing farther north impossible. Second, there was a seasonal shift in the southern limit of the albacore catches, the winter limit being farther south than the fall limit. The magnitude of this shift was about equal to the movement of certain surface isotherms, e.g., the 60°F. isotherm located between 41° and 42°N. on 170°W. during the fall moved south to between 32° and 33°N. at the same longitude during the following winter (fig. 2).

There are a number of records of Japanese commercial fishing in the general zone in which we took albacore during the winter of 1953-54. These are summarized in figure 3 and table 3. Most of the Japanese effort was concentrated to the west of 180° (fig. 3) whereas we surveyed the area from 180° east to 150°W. (fig. 2). Japanese fishing was confined to the zone lying between 28° and 35°N. latitude. The best Japanese catches were made during December and January, when a number of areas showed catches of 5 or more albacore per 100 hooks. Longitudinally, their best area appears to have been immediately west of 180° longitu (170°E. to 180°), however, from table 3 it is apparent that significant catches were made a far west as 141°E. during December 1953. I POFI's fishing during January-March 1954 an 1955 at only one station was the albacore catc rate as high as those of the good catches (>5. per 100 hooks) made by the Japanese to the we (compare figs. 2 and 3). This does not mean that the area immediately north of Hawaii is less productive than the area to the west, sinc only limited experimental fishing has been co pleted thus far, furnishing only a rough estim of albacore availability. It should be added he that the catch rates of the POFI 13-hook gear may not be strictly comparable with the catch rates of the Japanese 6-hook gear. Although the relative efficiency of the two types of gear in taking albacore has not yet been determine it has been shown for the central equatorial Pacific yellowfin tuna that 11-hook gear is les efficient in terms of catch per 100 hooks than 6-hook gear (Shomura and Murphy 1955).

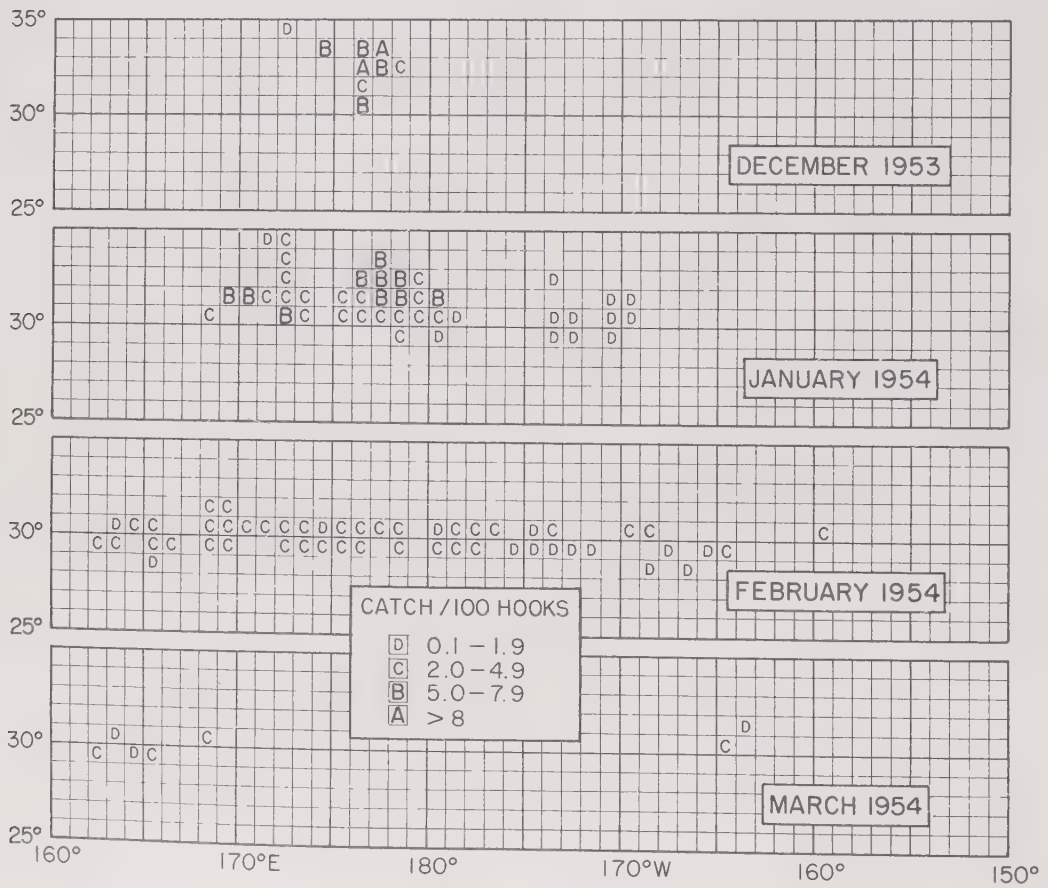

Figure 3.--Summary of some Japanese longline albacore catches (data from individual vessel reports transmitted to POFI by Mr. Toshizo Nomura).

Table 3.--Summary of Japanese commercial longline albacore catches (catch per 100 hooks) in the North Pacific. Data taken from Nomura et al. (1953-54)

Month	Area of fishing		Number of vessels	Times fished	Albacore per 100 hooks
	Latitude	Longitude			
Sept. 1953	37°-39°N.	158°-170°E.	3	54	0.04
Oct. 1953	37°-38°N.	151°-152°E.	1	16	0.03
	36°-38°N.	168°-174°E.	4	80	5.57
Nov. 1953	30°-35°N.	150°-159°E.	19	386	1.27
	32°-35°N.	160°-161°E.	2	34	4.68
	28°-32°N.	173°-174°E.	1	18	1.31
	33°-40°N.	150°-161°E.	6	106	1.34
	33°-38°N.	162°-172°E.	4	58	4.32
	32°-37°N.	174°-179°E.	1	23	2.84
	31°-35°N.	150°-174°E.	22	438	1.58
	25°-34°N.	179°-161°W.	4	100	0.65
	34°-35°N.	180°-170°W.	1	14	2.77
	34°-40°N.	150°-169°E.	11	187	2.49
Dec. 1953	30°-34°N.	158°-160°E.	11	204	2.72
	31°-35°N.	160°-163°E.	7	131	3.82
	30°-34°N.	170°E.-180°	14	234	6.86
	34°-35°N.	145°-147°E.	13	249	0.51
	30°-32°N.	141°-150°E.	7	86	4.73
	26°-31°N.	179°-168°W.	2	51	0.56
	32°-34°N.	172°-170°W.	1	16	1.09
	35°-37°N.	150°-174°E.	3	60	7.33
	30°-34°N.	151°-179°E.	32	569	4.76
	35°-38°N.	143°-148°E.	8	109	8.52
	30°-35°N.	141°-150°E.	20	335	1.69
	30°-35°N.	133°-139°E.	152	762	0.09
Jan. 1954	28°-30°N.	141°-145°E.	40	732	2.81
	28°-30°N.	150°-157°E.	2	38	3.07
	28°-30°N.	170°-178°E.	2	33	1.38
	30°-32°N.	151°-163°E.	6	123	2.29
	30°-32°N.	158°-168°E.	30	595	5.42
	30°-34°N.	175°-179°E.	7	123	5.30
	29°-30°N.	179°-170°W.	1	20	2.34
	30°-32°N.	170°-169°W.	1	18	0.72
	22°-30°N.	132°-171°E.	109	1559	2.42
	30°-34°N.	150°-178°E.	43	841	4.91
	35°-38°N.	142°-144°E.	14	132	6.98
	29°-35°N.	140°-148°E.	51	743	2.69
Feb. 1954	28°-30°N.	150°-160°E.	11	224	3.26
	28°-30°N.	160°-170°E.	13	265	3.11
	29°-30°N.	170°-179°E.	7	143	2.97
	29°-33°N.	149°-164°E.	3	60	3.21
	29°-31°N.	160°-173°E.	10	203	3.59
	30°-31°N.	168°-179°E.	6	131	3.16
	23°-30°N.	171°-158°W.	1	28	0.03
	30°-32°N.	154°-179°E.	19	394	3.40
March 1954	23°-30°N.	152°-157°E.	14	241	1.48
	29°-30°N.	160°-168°E.	5	97	3.21
	30°-32°N.	149°-166°E.	6	131	1.65
	29°-33°N.	160°-166°E.	7	156	3.43
	27°-30°N.	179°-167°W.	2	40	0.66
	30°-33°N.	150°-166°E.	13	287	2.82

Troll Catches. The albacore catches from both incidental and deliberate surface trolling are combined in figure 4. During January-March 1954 no albacore were taken in the 1,095 line-hours of trolling (fig. 4A), although albacore were taken on the longline gear during this period (fig. 2). During the fall of 1954 (figs. 4B and 4C), trolling yielded 56 albacore in 1,701 line-hours while during the following winter only 4 albacore in 2,911 line-hours. The highest catch rate of 8.8 albacore per 10 line-hours was made during the fall at about 42°N. latitude on 172°E. longitude (fig. 4B).

There is a striking contrast between the latitudinal locations of the fall and winter troll catches, for most of the fall catches were made north of 40°N. while the winter catches were all made between 30° and 35°N. latitude, a southward displacement roughly parallel to that of the longline catches.

No albacore or other fish were taken on the deep trolling gear used on Manning cruise 23. Albacore, however, were present below the surface in these waters as shown by the longline catch at five of the seven stations at which both types of gear were fished (table 4). We cannot yet consider deep trolling a complete failure, for only 7-1/2 hours have been devoted to this type of fishing.

Surface Sightings. To evaluate the relative productivity of the different areas, observations were made on bird flocks, fish schools, and aquatic mammals. During the period of our observations, the results (table 5) show that birds were most abundant during the fall months. This is of interest since the trolling records (fig. 4) show that most of the troll-caught albacore were taken during this period. The majority of the birds occurred to the south, however, between 30°N. and 40°N. latitude, whereas most of the albacore were taken north of 40°N. latitude.

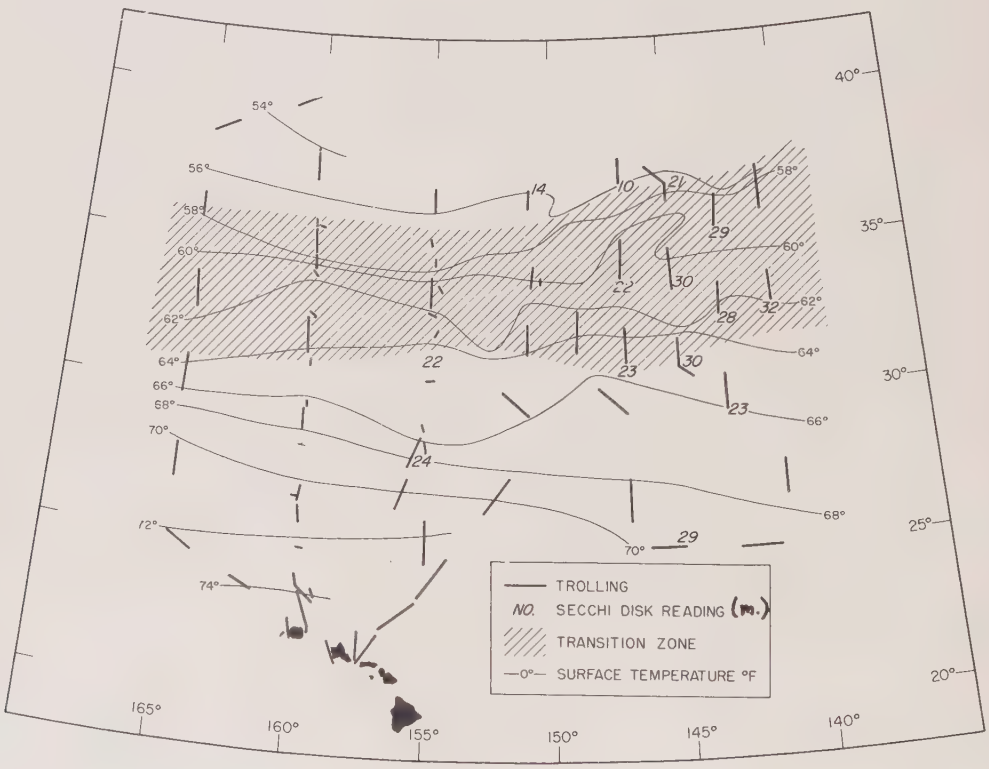

Figure 4A.--Albacore catch per 10-line hours of surface trolling; surface temperature contours and Secchi disk readings are indicated, Manning cruise 19 and Smith cruise 25, January-March 1954.

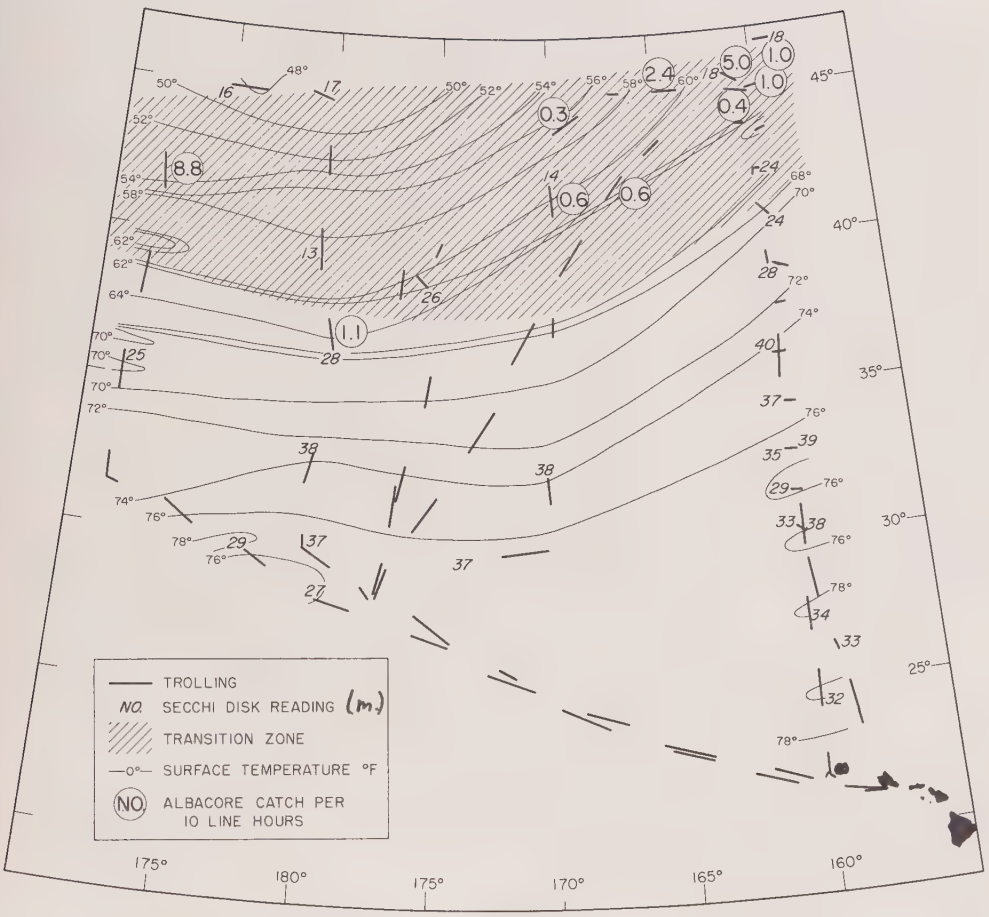

Figure 4B.--Albacore catch per 10-line hours of surface trolling; surface temperature contours and Secchi disk readings are indicated, Manning cruise 22 and Gilbert cruise 17, September-November 1954.

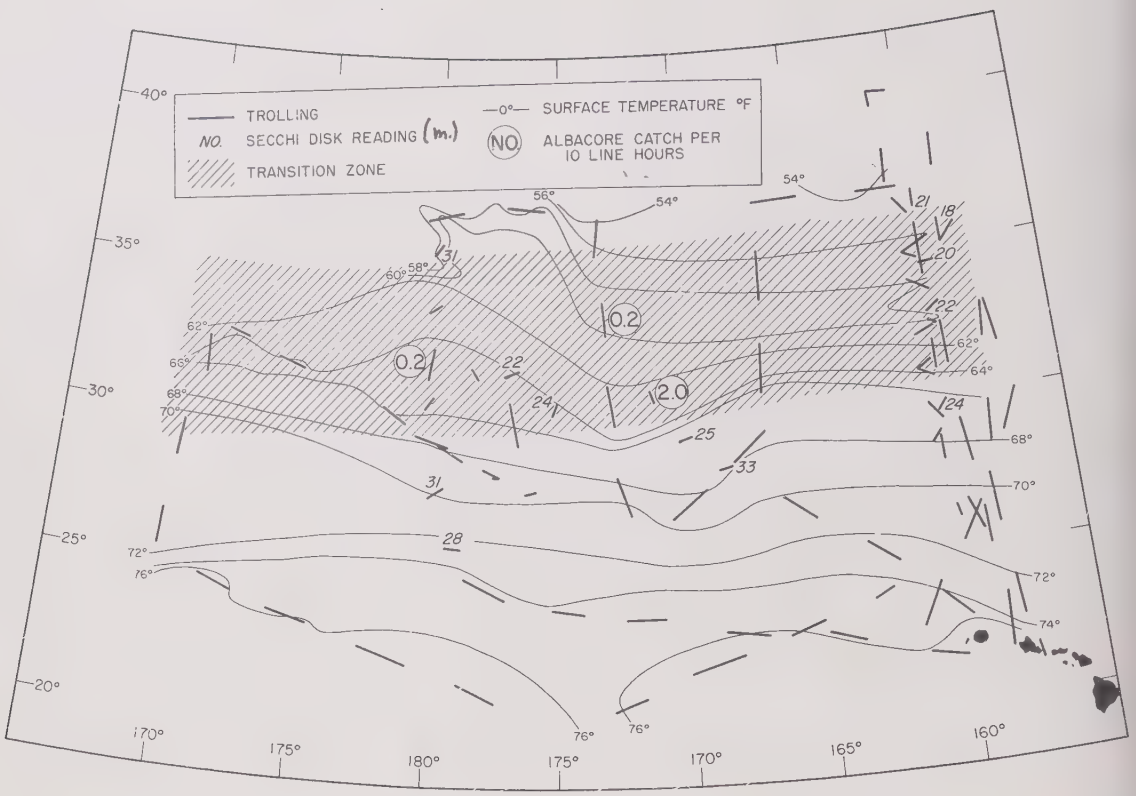

Figure 4C.--Albacore catch per 10-line hours of surface trolling; surface temperature contours and Secchi disk readings are indicated, Manning cruise 23, Gilbert cruise 18, and Smith cruise 27, December 1954-February 1955.

Table 4.--Results of the deep trolling experiment and a summary of the longline albacore catches for the same days, John R. Manning cruise 23, December 1954-February 1956

Date	Station	Hours trolled	Type of bait	Catch	Albacore catch on longline gear
Dec. 9	5	1	Feather	0	7
Dec. 14	8	1.5	Feather	0	7
Jan. 16	12	1	Sardine	0	5
Jan. 17	13	1	Sardine	0	1
Jan. 27	16	1	Sardine	0	0
Jan. 30	18	1	Sardine	0	0
Feb. 1	20	1	Sardine	0	2

ble 5.--Observations of bird flocks, fish schools, and mammals sighted more than 80 miles from land in the North Pacific[1/]

	Location		Nature of observation
	Latitude	Longitude	
1954			
. 24	38°35'N.	164°35'W.	Flock (11-50 birds) of petrels and shearwaters working over unidentified tuna school
. 24	38°30'N.	164°50'W.	Unidentified whale sighted
. 26	37°37'N.	160°09'W.	Seal sighted
. 3	33°40'N.	143°05'W.	3 porpoises sighted
. 16	22°40'N.	155°33'W.	Flock (11-50 birds) of terns working over unidentified, medium-sized tuna school
r. 16	22°40'N.	155°33'W.	Flock (200 birds) of terns working over unidentified, large-sized tuna school
t. 20	27°01'N.	159°59'W.	Unidentified whale sighted
t. 22	32°40'N.	159°54'W.	Four unidentified whales sighted
t. 29	42°45'N.	159°40'W.	Several albacore sighted breaking water
. 3	44°25'N.	168°30'W.	Several albacore sighted breaking water
. 9	39°20'N.	169°20'W.	Flock (< 10 birds) of petrels and/or shearwaters
. 10	37°00'N.	171°10'W.	Flock (11-50 birds) of petrels and/or shearwaters
. 10	37°00'N.	171°10'W.	Flock (> 50 birds) of petrels and/or shearwaters
. 11	33°20'N.	173°30'W.	Flock (> 50 birds) of terns, petrels, shearwaters; some evidence of fish school
. 17	32°30'N.	176°20'W.	Flock (200-300 birds) of boobies, petrels, and/or shearwaters; evidence of fish school
17	32°10'N.	176°30'W.	Flock (75 birds) of petrels
. 17	31°30'N.	176°30'W.	Flock (11-50 birds) of petrels and/or shearwaters
. 17	31°50'N.	176°30'W.	Flock (200 birds) of terns, petrels and/or shearwaters working over unidentified tuna school
19	33°00'N.	176°00'W.	Flock (100 birds) of petrels and/or shearwaters
. 20	34°50'N.	175°30'W.	Flock (50 birds) of petrels
20	35°00'N.	175°30'W.	Flock (100 birds) of petrels
22	37°30'N.	175°00'W.	Flock (> 50 birds) of petrels and/or shearwaters
22	37°30'N.	175°00'W.	Flock (> 50 birds) of petrels and/or shearwaters
. 24	44°55'N.	177°50'W.	Flock (200-300 birds) of terns with few albatross
. 25	40°10'N.	175°00'W.	Flock (> 300 birds) of petrels working over unidentified, large-sized tuna school
19	23°40'N.	158°00'W.	Small school of medium-sized (approx. 7 lb.) tuna; no accompanying birds
9	21°51'N.	168°46'W.	2 unidentified whales sighted
12	21°20'N.	178°45'W.	Unidentified whale sighted
. 14	29°35'N.	179°40'W.	School of small tuna (approx. 4 lb.) sighted; no birds present
. 17	28°45'N.	169°55'E.	Unidentified fish (30-40 lb.) sighted breaking water
. 18	35°48'N.	179°49'W.	Small, light brown turtle sighted near longline buoy
. 27	31°41'N.	176°29'W.	Several killer whales sighted near longline set
. 6	36°25'N.	173°15'W.	Flock (11-50 birds) of petrels with few Laysan albatross working over unidentified fish school
. 7	33°30'N.	173°06'W.	Unidentified whale sighted

[1/] Observations have been listed chronologically and irrespective of locality or vessel. The hbers of birds sighted are estimates made by experienced fishermen.

Environmental Conditions

In the North Pacific, north of the Hawaiian nds, there is a transition zone between two currents which may prove to be the significant oceanographic feature influencing the distribution and abundance of albacore. A detailed description of this zone for the winter of 1953-54 has been

given by McGary and Stroup (MS)[1/]. Briefly, it is an area of mixing created by shearing action between two easterly flowing currents, the Aleutian Current (relatively cold and low salinity water) to the north and the North Pacific Current (relatively warm and high salinity water) to the south. The zone is characterized by abrupt changes in temperature and salinity and by an increase in inorganic phosphate as compared with the North Pacific Current (McGary and Stroup MS). Increased biological activity is suggested by somewhat lower water transparency values (fig. 4) than prevail to the north and south.

Nearly all of the troll-caught albacore were taken within the transition zone (fig. 4), and the longline-caught albacore were taken either in the transition zone (fig. 5A) or just to the north (figs. 5B, 5C), suggesting a close

[1/] McGary, James W. and E. D. Stroup. Mid-Pacific oceanography, Part VIII, Middle latitude waters, January-March 1954. The authors point out that an adequate name for this zone has yet to be found. It has at times been called the Arctic Convergence and the North Polar Front.

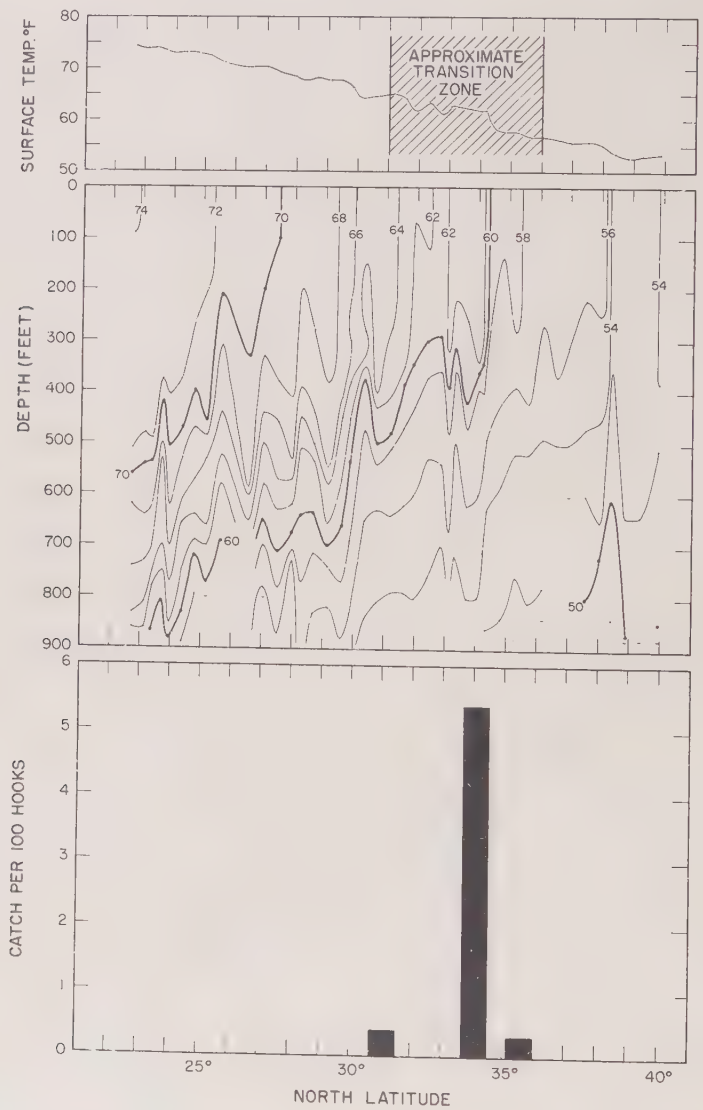

Figure 5A.--Vertical temperature sections and longline catch of albacore (catch/100 hooks) along 160° W. longitude during the three survey periods, Manning cruise 19, January-March 1954.

ationship between the albacore and this anographic feature.

The data from the three fishing cruises ered by this report give evidence that the nsition zone undergoes seasonal meridional fts, south in the winter and north in the fall. he tuna are associated with this feature, they y be expected to show a similar seasonal shift occurrence. In figure 5 the vertical tempera- e sections and the longline albacore catches ng 160°W. longitude are shown for the three vey periods. During the winter of 1953-54 . 5A) the transition zone was located approxi- tely between 31° and 36°N. latitude, with the face temperature varying between 58° and F. During the fall of 1954 (fig. 5B) the trans- n zone had been displaced northward to between and 46°N. latitude. The surface temperature he transition zone during this period ranged m about 59° to 68°F. During the subsequent ter (1954-55) the transition zone again moved th to between 31° and 36°N. latitude, with the surface temperature varying from 58° to 69°F. (fig. 5C). The troll-catches of albacore, as shown in figures 4A-4C, show that the albacore were taken farther north in the fall than in the winter. The histograms in figures 5A-5C show a similar meridional shift in the location of the longline-caught albacore with season. Thus, the albacore appears to make seasonal meridional movements similar to the movement of the transition zone.

Table 6 shows the surface temperatures at which albacore were taken by trolling. Catches were most frequently made in temperatures between 59° and 61°F. These temperatures fall within the range which generally delineates the transition zone at the surface.

However, it should be pointed out that surface temperature alone cannot always be relied upon to indicate the presence of either albacore or the transition zone. This is clearly shown in the case of the high catch of 25 albacore

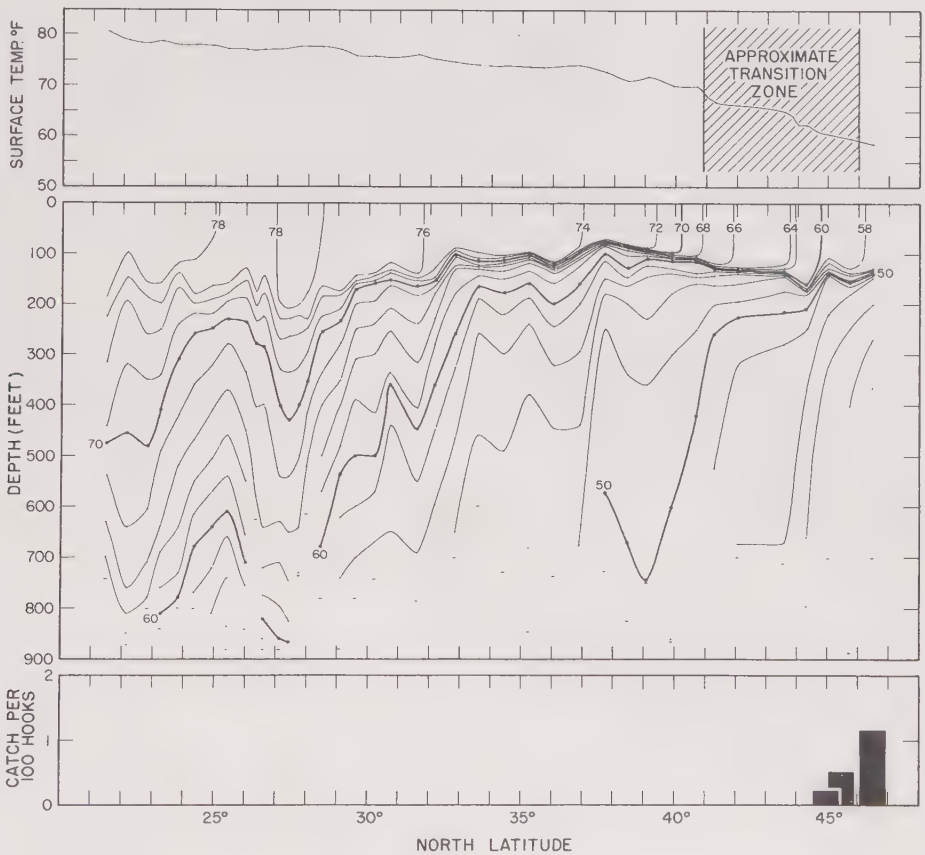

Figure 5B.--Vertical temperature sections and longline catch of albacore (catch/100 hooks) along 160°W. longitude during the three survey periods, Manning cruise 22, September-November 1954.

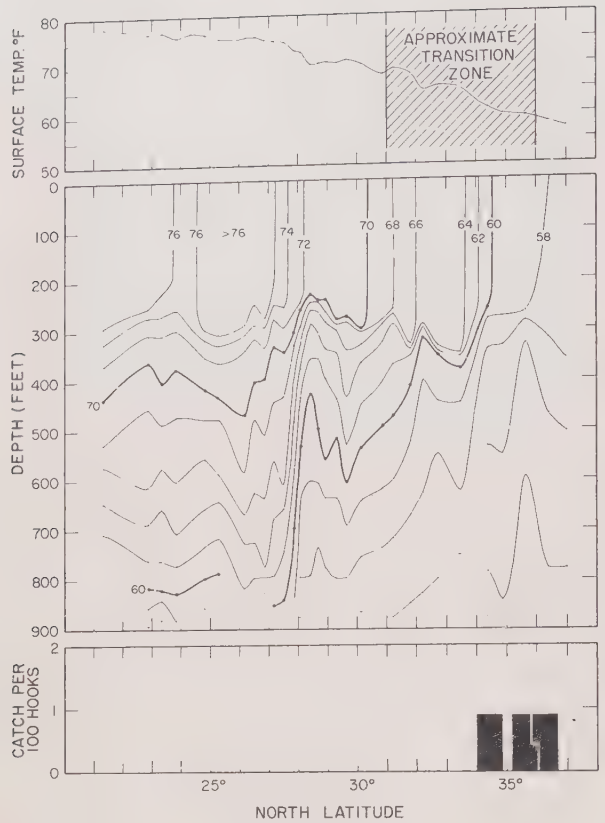

Figure 5C.--Vertical temperature sections and longline catch of albacore (catch/100 hooks) along 160°W. longitude during the three survey periods, Manning cruise 23, December 1954-February 1955.

Table 6.--Trolling catch of albacore in relation to surface temperature

Surface temperature	Number of albacore caught[1/]	Catch Total	Frequency of catch
°F.			
50	-	-	-
51	-	-	-
52	25, 2	27	2
53	1	1	1
54	-	-	-
55	-	-	-
56	-	-	-
57	2	2	1
58	-	-	-
59	1, 2, 3, 6, 2, 1, 1	16	7
60	1, 2, 1	4	3
61	1, 1	2	2
62	-	-	-
63	3	3	1
64	1, 2	3	2
65	1	1	1
66	-	-	-
Questionable	1	1	1
Total		60	21

[1/] Individual catches are listed to show the frequency of catches made at the various temperatures.

(8.8 per 10 line-hours of trolling) made at 42°N. on 172°E. longitude during the fall period (fig. 4B). In spite of the unusually low surface temperature of 52°F. this area was within the transition zone. This low temperature was probably the result of the mixing of surface and deeper waters associated with the recent passage of a low pressure cell with winds up to 65 knots.

Vertical Distribution of Albacore

Previous studies by POFI of the vertical distribution of tuna have been based on relative hook depth (Murphy and Shomura 1953a) because a method of routinely determining the absolute depth of the gear was lacking. On two of the three cruises discussed in this paper (Manning cruises 22 and 23) chemical sounding tubes were used to give direct measurements of the depth of fishing.

The sounding tubes were of glass capillary tubing, 4 mm. in outside diameter and 640 mm. in length with an inner chemical coating which dissolves upon contact with water. While in use, the tubes are encased in protective metal cylinders. When submerged, water is forced up the tube by the pressure, leaving a line of demarkation which indicates the maximum depth when the tube is read against a scale.

The accuracy of the calibration of the sounding tubes under conditions of prolonged immersion (i.e., 5 to 10 hours) was checked by attaching them to the longline together with a bathythermograph. The results of 26 tests are shown in figure 6. The agreement between the sounding tube readings and the bathythermograms suggests that the former may be used to determine the depth of the longline with reasonable accuracy. Variation of the points about the theoretical line shown in figure 6 is within the range of error of reading the two instruments.

To estimate routinely the fishing level of the longline gear, sounding tubes were

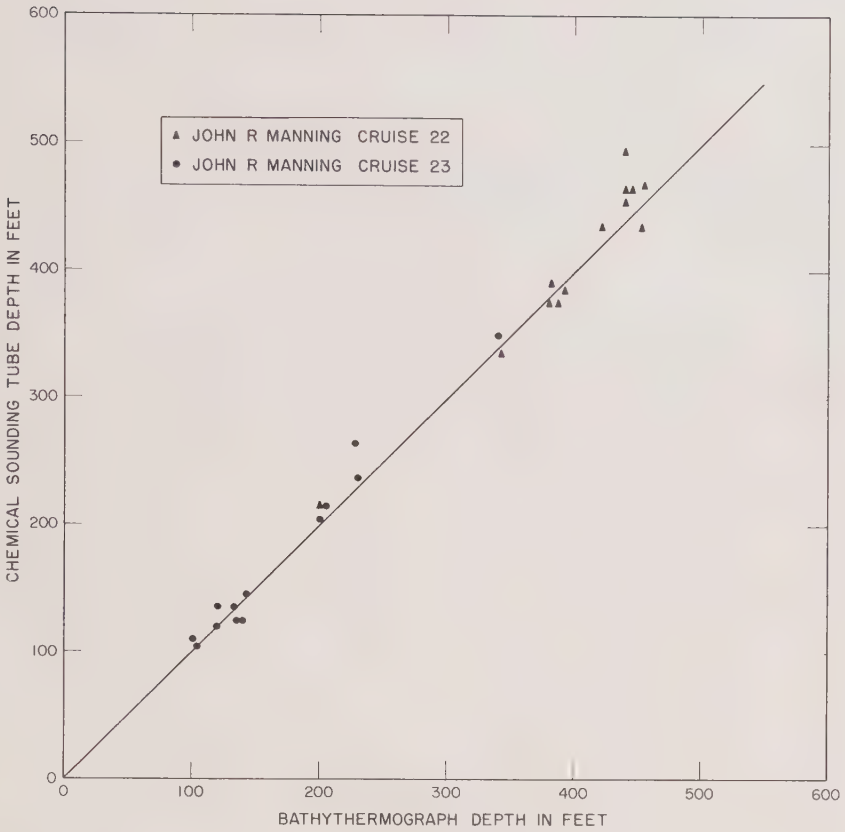

Figure 6.--Calibration of chemical sounding tubes with bathythermograph on John R. Manning cruises 22 and 23. Each point denotes readings obtained from one lowering of the BT with sounding tube attached.

ched to the proximal end of the deepest branch (number 7) on 2 to 4 baskets at 31 stations ng Manning cruises 22 and 23. They were d on centrallylocated baskets of the 5- and thom floatline gear in order to avoid atypi- easurements from the end baskets.

Table 7 (a, b) gives the depths recorded he two cruises for both the 5- and 15-fathom tline gear. On cruise 22 the maximum depth the 5-fathom gear ranged from 306 to 504 feet averaged 405 feet. The 15-fathom gear fished per, averaging 432 feet with a range of depths n 336 to 450 feet. On cruise 23 the difference more pronounced, principally because the 5- om gear was set without the usual slack. The thom gear averaged 328 feet and ranged from to 504 feet. The 15-fathom gear fished about eet deeper, averaging 410 feet and ranging n 288 to 522 feet.

The albacore catches by relative depths apture are given in table 8. In general, alba- e were caught in approximately equal numbers throughout the range of fishing depths, a different situation from that in the equatorial region, where they are taken in the greatest numbers on the deepest hooks (Murphy and Shomura 1953b). This difference in the vertical distribution of the North Pacific albacore and equatorial albacore may be associated with the difference in water temperatures between the two areas. The water temperatures which occur at the surface in the North Pacific are found in the deeper layers near the Equator; e.g., the 60°F. isotherm which is at or near the surface in the North Pacific is located at depths exceeding 500 feet in equatorial waters (Murphy and Shomura 1953a, b). Thus even near the Equator, where albacore exist in sizeable numbers, they appear to occupy a similar environment temperature-wise as they do in the northern region.

A comparison of the maximum depth of fishing, the depth of the thermocline, and the albacore distribution by relative hook depth indicates that albacore may possibly be foraging

Table 7a.--Depth of deepest fishing hook of the 5- and 15-fathom floatline gear as estimated by chemical sounding tubes

John R. Manning cruise 22

Station	5-fathom floatline gear		15-fathom floatline gear		Thermocline depth
	No fish on basket	Fish on basket	No fish on basket	Fish on basket	
	feet	feet	feet	feet	feet
1	384	534	-	-	130
3	360	378	-	-	140
	384	-	-	-	-
5	-	-	450	-	130
	-	-	432	-	-
	-	-	450	-	-
7	-	444	-	-	90
	-	552	-	-	-
	-	432	-	-	-
9	450	-	-	-	100
	414	-	-	-	-
	432	-	-	-	-
11	384	408	-	-	120
	408	-	-	-	-
13	462	-	450	-	70
14	504	-	-	-	90
	408	-	-	-	-
	420	-	-	-	-
15	432	>600	-	-	100
	-	522	-	-	-
17[1/]	282	-	-	-	120
	288	-	-	-	-
18[1/]	-	360	336	-	100
	-	342	-	-	-
19	420	-	408	-	120
	384	-	-	-	-
21	384	396	-	-	100
	402	-	-	-	-
24	306	336	-	-	160
	342	-	-	-	-
26	414	450	402	402	200
28	-	414	-	444	220
	-	-	-	438	-
$\bar{x}$	405		432		

[1/] Not included in calculating the mean because of atypical setting prodecure.

Table 7b.--Depth of deepest fishing hook of the 5- and 15-fathom floatline gear as estimated by chemical sounding tubes (continued)

John R. Manning cruise 23

Station	5-fathom floatline gear		15-fathom floatline gear		Thermocline depth
	No fish on basket	Fish on basket	No fish on basket	Fish on basket	
	feet	feet	feet	feet	feet
1	420	-	-	414	265
	414	-	-	402	-
3	378	-	468	-	325
	336	-	474	-	-
5	348	-	-	450	260
	318	-	-	492	-
7	372	372	360	-	270
	-	-	492	-	-
8	270	-	390	492	280
	369	-	-	-	-
9	252	330	-	-	360
10	324	297	396	366	290
11	264	-	480	-	355
	-	-	342	-	-
12	222	-	297	378	230
	276	-	-	-	-
13	414	252	522	-	240
	-	-	288	-	-
14	360	-	390	-	260
	249	-	342	-	-
15	504	-	456	-	380
	276	-	426	-	-
16	315	-	372	360	470
	255	-	-	-	-
17	327	-	354	-	385
	354	-	522	-	-
18	249	324	468	-	320
	-	-	360	-	-
$\bar{x}$	328		410		

Table 8.--Summary of albacore catch by relative hook depth

a. Gear with 5-fathom floatlines

Cruise	Hook number						
	1 and 13	2 and 12	3 and 11	4 and 10	5 and 9	6 and 8	7
anning-19 Jan.-Mar. 1954)	2	3	4	3	2	7	4
anning-22 Sept.-Nov. 1954)	1	2	2	3	1	-	1
anning-23 Dec. 1954-Feb. 1955)	4	1	2	4	4	4	3

Table 8.--Summary of albacore catch by relative hook depth (continued)

b. Gear with 15-fathom float lines

Cruise	Hook number						
	1 and 13	2 and 12	3 and 11	4 and 10	5 and 9	6 and 8	7
Manning-19 (Jan.-Mar. 1954)	2	4	2	5	2	4	2
Manning-22 (Sept.-Nov. 1954)	4	6	1	-	2	2	-
Manning-23 (Dec. 1954-Feb. 1955)	3	2	2	6	5	6	4

below as well as above the thermocline in northern waters. It may be calculated from table 7 that on Manning cruise 22 the average maximum fishing depth of the 5-fathom gear was 405 feet, which was considerably deeper than the average thermocline depth of 124 feet, while on cruise 23 the average maximum depth of fishing (328 feet) was approximately at the depth of the thermocline (321 feet). On both cruises the 15-fathom gear was well below the thermocline, with an average maximum depth of 432 feet on cruise 22 and 410 feet on cruise 23. If it is accepted that the deeper hooks were fishing below the thermocline, the vertical distribution of the albacore catches (table 8) shows that some of them were caught below the thermocline. We cannot as yet accept these findings as final in view of the small catch and the possibility that all of the albacore could have been caught at shallower depths during the retrieving of the line. This question can only be settled with more data than are presently available.

Size of Albacore

The size distribution of the albacore taken in the North Pacific during the three survey periods is shown in figure 7 in which catches from longline and trolling gear are treated separately. It is seen that the longline-caught albacore had a wider size range than the troll-caught albacore. During the fall, troll catches ranged in size from 52 to 74 cm. (7 to 20 pounds) while the longline-caught albacore ranged from 54 to 114 cm. (8 to 68 pounds). This indicates that the trolling gear samples chiefly the smaller albacore, while both small and large fish are taken on the longline. We do not as yet know how efficiently the longline gear samples the smaller fish, nor whether or not the small fish were chance captures at the surface during the hauling of the line. But if small albacore were being taken only during hauling, then they should all have been alive when landed. However, only 17 of the 30 small albacore (less than 80 cm.)[2/] taken were landed alive, while among fish larger than 80 cm., 62 out of 88 were alive (table 9). The implication is that small albacore are not being taken only at the surface during the hauling of the gear.

Table 9.--Summary of longline-caught albacore landed alive

Cruise	Total number of albacore < 80 cm.	Number taken alive	Total number of albacore >80 cm.	Numbe taken alive
Manning-19 (Jan.-Mar. 1954)	3	-	41	30
Manning-22 (Sept.-Nov. 1954)	21	12	4	3
Manning-23 (Dec. 1954-Feb. 1955)	6	5	43	29
Total	30	17	88	62
		57%		70%

A majority of the longline-caught albacore taken during the first winter (January-March 195 were large, 93 percent of the catch measuring over 80 cm. (25 pounds). During the fall (September-October 1954) the reverse was true, with the catch made up mostly of small fish and with those larger than 80 cm. constituting only 19 percent of the catch. Finally, the results from

[2/] All troll-caught albacore measured less than 80 cm. (fig. 7) therefore it is assumed provisionally that 80 cm. is the approximate size at which "small" and "large" fish are separated.

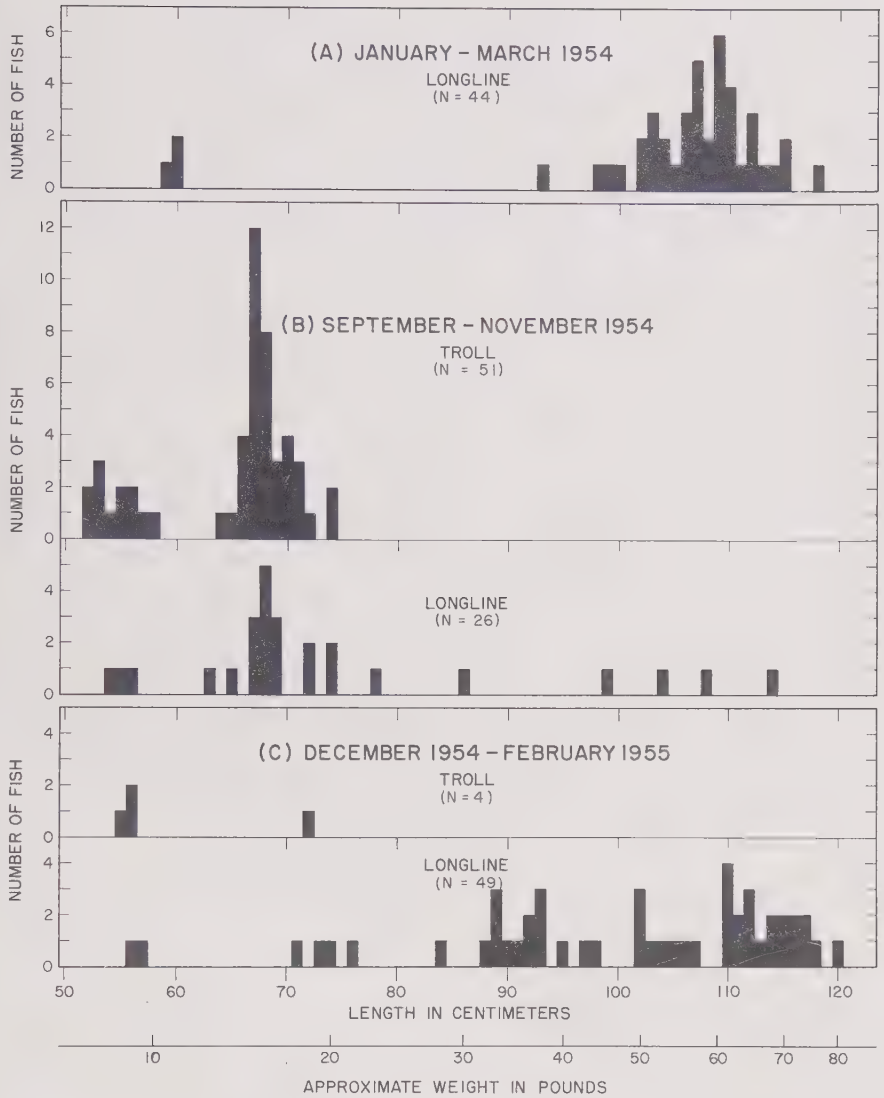

Figure 7.--Length frequency of albacore taken during the three surveys. A. January-March 1954, B. September-November 1954, C. December 1954-February 1955.

second winter of fishing (December 1954-bruary 1955) again showed larger fish domi-ing the catch, with 88 percent of the albacore ch larger than 80 cm. The almost complete sence of small albacore (less than 80 cm.) m both the longline and trolling catches dur-; both winters suggests that the small fish ich were present during the fall had moved of the area with the approach of winter.

Sex Ratio and Maturity of Albacore

The results of the albacore sex deter-nations are given in table 10. A paucity of

Table 10.--Sex of albacore taken on Manning cruises 19, 22, and 23

Cruise	Total number observed	Number of males	Number of females	Ratio (♂:♀)
Manning-19 (Jan.-Mar. 1954)	15	12	3	4:1
Manning-22 (Sept.-Nov. 1954)	11	5	6	1:1.2
Manning-23 (Dec. 1954-Feb. 1955)	14	12	2	6:1

data, further reduced by the tagging of viable albacore, precludes any analysis at this time. Field examination of the gonads failed to reveal sexually mature fish, most of them possessing thin, ribbon-like gonads in the earliest stages of sexual development.

Tagging of Albacore

One of the aims of the albacore investigation is to determine the relationships of the albacore taken in different parts of the North Pacific, i.e., whether the albacore population of the North Pacific is composed of one or many races or stocks of fish. Recoveries made by the Japanese of albacore tagged off California (Ganssle and Clemens 1953, Blunt 1954) demonstrate ocean-wide migrations. Notable among these is the recovery made on June 23, 1953, by Japanese fishermen about 550 miles southeast of Tokyo (Ganssle and Clemens 1953). This fish had been tagged and released off Los Angeles Harbor, California, on August 4, 1952, 324 days before recapture. The albacore had traversed a straight-line distance of 4,900 miles.

In order to define the relationship of the central Pacific stocks, we have tagged all viable albacore, thus far releasing 79 fish (table 20, Appendix). Tags (Type G) and tagging methods have been essentially the same as those used in California (Wilson 1953).

OTHER FISHES

Other Tunas

In addition to the albacore, the species of tuna taken on longline (tables 11 to 13, Appendix) and trolling (table 21, Appendix) gear were the bigeye, yellowfin, skipjack, and little tunny. Of these, the bigeye, which is of commercial importance in Hawaii and Japan, was by far the most abundant species in the longline catch. Bigeye appeared in the catch at 27 of the 52 stations fished, the biggest single catch (30 bigeye, or 3.85 fish per 100 hooks) being made on Manning cruise 19 at 30°54'N., 159°54'W., just south of the biggest albacore catch, which was made at 33°58'N. during the same period. The distributional pattern of the bigeye during the three survey periods (fig. 8) indicates a north-south shift paralleling that of the albacore; during the fall bigeye were taken as far north as 40°N., but during the winter they were taken only as far north as 34°N. (fig. 8). Bigeye and albacore were taken together at only 6 of the 41 stations which yielded tuna, and most of the bigeye were taken farther south than the albacore, indicating a preference for a more tropical environment.

Yellowfin and skipjack were sporadicall taken on the longline and trolling gear and then generally south of the albacore, while the singl little tunny was caught by trolling in definitely tro pical waters. As for the small catch of yellowfin Nakamura (1951) says that this species ranges as far north as 35°N. latitude and is abundant in the North Pacific during the summer, a period for which we do not at present have data.

Sharks

The four species of shark commonly take on the longline gear in the North Pacific were the bonito, great blue, thresher, and white-tipped shark. Of the four species, the great blue was by far the most frequently caught and is probably the most abundant species of shark in the area. It was taken at 50 of the 52 fishing stations, wit the highest day's catch of 40 at station 28 (40° 12'N., 174°56'W.) on cruise 22 of the Manning during October 1954 (tables 17 to 19, Appendix)

The immediate importance of sharks to the tuna longline fishery lies in the amount of damage they inflict on the tuna catch. In the equatorial area shark-damaged tuna comprise as much as 20 percent of the catch (Murphy and Shomura 1955). In comparison, only 3 of a total of 262 tuna (1.1 percent) taken on the long line gear in the North Pacific were shark-bitten in spite of the heavy population of great blue shark indicated by the longline catches.

Miscellaneous Species

Among the miscellaneous species of fish taken on the longline gear were the lancet fish, broadbill swordfish, striped marlin, black mar lin, short-nosed spearfish, sunfish, dolphin, wahoo, and a newly described species of pelagi sting ray (Ishiyama and Okada 1955). Only the lancet fish, among these, were taken with any regularity (tables 17 to 19, Appendix), and they were found to range widely over the areas fishe

One pelagic sting ray was captured at station 15 (cruise 19) at 34°41'N., 154°52'W. and another at station 13 (cruise 23) at 33°50'N. 179°44'W.

Among the troll catches of fish other than tunas (table 22, Appendix) the dolphin was most frequent. It was taken in the southern sectors of the survey areas.

SUMMARY

1. Albacore were taken on the longline gear during all three surveys, with the highest

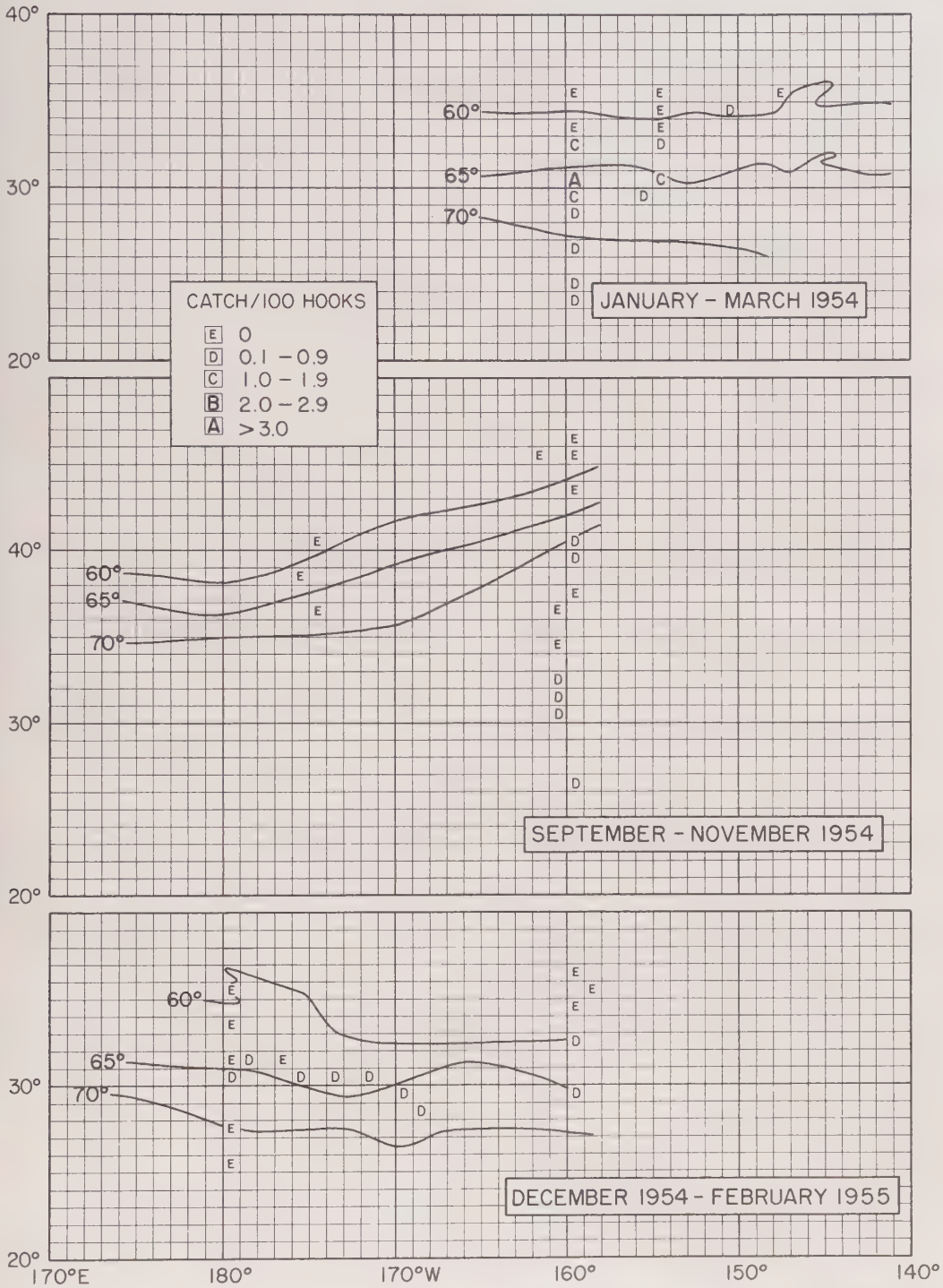

Figure 8.--Summary of POFI longline bigeye catches in the North Pacific.

single catch of 42 albacore made during the first winter of fishing. As evidenced by Japanese catch data, substantial numbers of albacore were present as far west as 141°E. longitude during the winter of 1953-54.

2. Trolling for albacore was most successful during the fall survey, with the highest catch of 8.8 albacore per 10 line-hours of trolling made at 42°N., 172°E. Trolling during both winter surveys was poor. No albacore were taken during the first winter and only 4 during the second winter of fishing.

3. The albacore population moves north and south seasonally. Fish were taken only north of 35°N. latitude during the fall but were taken as far south as 29°N. latitude during the winter. This shift in albacore distribution appears to be related to a similar latitudinal shift in the transition zone, which is a zone of mixing between two easterly flowing currents, the North Pacific and the Aleutian. During the fall the transition zone was considerable farther north than during the winter.

4. A study of the vertical stratification of albacore indicated their presence throughout the range of depths fished by the longline gear.

5. By means of chemical sounding tubes the average maximum depth of the 5-fathom floatline gear was found to be 405 feet on Manning cruise 22 and 328 feet on Manning cruise 23. The average maximum depth of the 15-fathom floatline gear was 432 feet and 410 feet for the two cruises respectively.

6. The albacore taken on the longline gear ranged in size from 54 to 120 cm. (8 to 79 pounds), while all of the troll-caught albacore were smaller than 74 cm. (20 pounds). The majority of the small albacore (less than 80 cm.) were taken on the longline and trolling gear during the fall survey, and they were noticeably absent from both winter surveys, indicating a movement of small albacore from the area.

7. None of the albacore taken on the longline or trolling gear were in an advanced stage of sexual maturity.

8. A total of 79 albacore, 54 bigeye, and 1 yellowfin were tagged with the California-type plastic vinylite tags.

9. Bigeye tuna were regularly taken during al three survey periods, usually south of the area of albacore catches. The bigeye rang in size from 82 to 180 cm. (26 to 265 pound

10. Damage to longline-caught fish by sharks was negligible at 1.1 percent even though shark populations were apparently quite large. Shark damage in equatorial waters often reaches as high as 20 percent.

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APPENDIX

ble 11.--Summary of the tuna catch, John R. Manning cruise 19[1/], January-March 1954

Station	Date	Noon position		Catch per 100 hooks			
		Latitude	Longitude	Albacore	Bigeye	Yellowfin	Skipjack
1	Jan. 16	23°36'N.	159°148W.	-	0.40	-	-
2	Jan. 21	24°50'N.	159°40'W.	-	0.26	0.26	-
3	Jan. 22	26°28'N.	159°39'W.	-	0.13	-	-
4	Jan. 23	28°12'N.	159°44'W.	-	0.40	0.13	0.26
5	Jan. 24	29°44'N.	159°56'W.	-	1.79	-	-
6	Jan. 25	30°54'N.	159°54'W.	0.40	3.85	-	0.13
7	Jan. 26	32°29'N.	159°50'W.	-	1.92	-	-
8	Jan. 27	33°58'N.	159°44'W.	5.38	-	-	-
9	Jan. 28	35°27'N.	159°38'W.	0.26	-	-	-
10	Feb. 19	29°07'N.	155°12'W.	-	0.51	-	-
11	Feb. 20	30°36'N.	154°50'W.	-	1.03	-	0.13
12	Feb. 21	32°12'N.	154°48'W.	-	0.77	-	-
13	Feb. 22	32°43'N.	154°50'W.	-	0.26	-	-
14	Feb. 25	33°46'N.	154°48'W.	-	-	-	-
15	Feb. 26	34°41'N.	154°52'W.	-	-	-	-
16	Feb. 27	35°16'N.	155°02'W.	-	-	-	-
17	Mar. 1	34°02'N.	150°26'W.	-	0.26	-	-
18	Mar. 3	35°57'N.	147°00'W.	-	-	-	-

[1/] 13 hooks per basket; 754 hooks fished at station 1, 780 hooks at all others.

Table 12.--Summary of the tuna catch, Manning cruise 22, September-October 1954

Station	Date	Noon position		Number of hooks	Catch per 100 hooks	
		Latitude	Longitude		Albacore	Bigeye
1	Sept. 15	26°17'N.	159°13'W.	780	-	0.64
3	Sept. 17	30°14'N.	160°05'W.	780	-	0.38
5	Sept. 18	31°26'N.	160°07'W.	780	-	0.64
7	Sept. 19	32°50'N.	160°05'W.	728	-	0.27
9	Sept. 20	34°25'N.	160°01'W.	780	-	-
11	Sept. 21	36°02'N.	160°05'W.	780	-	-
13	Sept. 22	37°43'N.	159°31'W.	780	-	-
14	Sept. 23	39°02'N.	159°38'W.	780	-	0.26
15	Sept. 24	40°45'N.	159°50'W.	780	-	0.64
17	Oct. 2	43°37'N.	159°43'W.	520	-	-
18	Oct. 3	45°02'N.	159°40'W.	520	0.19	-
19	Oct. 4	46°30'N.	159°18'W.	780	1.15	-
21	Oct. 5	45°31'N.	161°16'W.	780	0.51	-
24	Oct. 21	36°22'N.	174°35'W.	780	0.38	-
26	Oct. 24	38°40'N.	175°27'W.	767	1.17	-
28	Oct. 25	40°12'N.	174°56'W.	754	0.13	-

Table 13.--Summary of the tuna catch, John R. Manning cruise 23, December 1954-February 1955

Station	Date	Noon position		Number of hooks	Catch per 100 hooks	
		Latitude	Longitude		Albacore	Bigeye
1	Dec. 6	29°32'N.	159°56'W.	715	-	0.70
3	Dec. 8	32°43'N.	159°54'W.	780	-	0.13
5	Dec. 9	34°23'N.	159°48'W.	780	0.90	-
7	Dec. 12	36°14'N.	159°54'W.	780	0.90	-
8	Dec. 14	35°35'N.	158°21'W.	780	0.90	-
9	Jan. 12	25°52'N.	179°26'W.	773	-	-
10	Jan. 13	27°51'N.	179°30'W.	780	-	-
11	Jan. 15	30°25'N.	179°42'E.	520	0.38	0.38
12	Jan. 16	31°49'N.	179°43'E.	520	0.96	-
13	Jan. 17	33°50'N.	179°44'W.	773	0.13	-
14	Jan. 18	35°48'N.	179°49'W.	754	0.27	-
15	Jan. 20	31°25'N.	178°08'W.	780	0.64	0.13
16	Jan. 27	31°41'N.	176°29'W.	780	-	-
17	Jan. 28	30°42'N.	175°01'W.	780	1.03	0.13
18	Jan. 30	30°52'N.	173°10'W.	780	-	0.13
19	Jan. 31	30°59'N.	171°14'W.	780	0.51	0.64
20	Feb. 1	29°30'N.	169°47'W.	780	0.26	0.13
21	Feb. 2	28°21'N.	168°08'W.	780	-	0.26

Table 14.--Time taken for setting and hauling the longline gear, John R. Manning cruise 19, January-March 1954

Station	Set				Haul			Fish-handling break
	Number of baskets set		Time started to set	Time taken for setting	Time started to haul	Time taken for hauling		
	5-fathom gear	15-fathom gear				5-fathom gear	15-fathom gear	
				min.		min.	min.	min.
1	28	30	0653	87	1236	129	108	30
2	30	30	0655	86	1229	119	130	27
3	30	30	0700	84	1229	111	122	28
4	30	30	0649	78	1257	96	100	27
5	30	30	0647	80	1230	102	105	33
6	30	30	0648	84	1228	110	110	31
7	30	30	0647	81	1228	109	113	31
8	30	30	0645	78	1239	94	120	37
9	30	30	0654	78	1225	111	108	31
10	30	30	0614	80	1220	106	137	32
11	30	30	0615	80	1216	119	137	28
12	30	30	0619	81	1220	104	120	-
13	30	30	0622	83	1211	140	176	-
14	30	30	0618	82	1213	111	110	33
15	30	30	0625	82	1208	106	119	36
16	30	30	0618	82	1213	125	125	33
17	30	30	0613	83	1302	135	113	-
18	30	30	0615	85	1209	126	130	20

Table 15.--Time taken for setting and hauling the longline gear, John R. Manning cruise 22, September-November 1954

Station	Set				Haul			Fish-handling break
	Number of baskets set		Time started to set	Time taken for setting	Time started to haul	Time taken for hauling		
	5-fathom gear	15-fathom gear				5-fathom gear	15-fathom gear	
				min.		min.	min.	min.
1	30	30	0532	78	1213	120	135	35
3	30	30	0538	77	1234	107	120	29
5	30	30	0540	79	1227	129	125	27
7	27	29	0544	74	1213	102	112	30
9	30	30	0546	74	1219	107	97	28
11	30	30	0540	74	1208	114	106	30
13	30	30	0543	77	1216	113	111	-
14	30	30	0544	71	1218	114	124	-
15	30	30	0602	73	1211	156	126	29
17	20	20	0618	68	1215	95	100	-
18	20	20	0646	60	1226	85	95	-
19	30	30	0546	76	1205	116	109	-
21	30	30	0601	78	1217	132	126	-
24	30	30	0635	85	1210	102	111	-
26	30	29	0627	78	1225	136	117	24
28[1/]	30	30	0620	80	1203	-	-	-

[1/] Gear picked up in severe storm, 2 baskets lost, hauling times for some baskets not recorded.

Table 16.--Time taken for setting and hauling the longline gear, John R. Manning cruise 23, December 1954-February 1955

Station	Set				Haul			Fish-handling break
	Number of baskets set		Time started to set	Time taken for setting	Time started to haul	Time taken for hauling		
	5-fathom gear	15-fathom gear				5-fathom gear	15-fathom gear	
				min.		min.	min.	min.
1	25	30	0648	82	1156	125	129	32
3	30	30	0612	86	1217	127	128	36
5	30	30	0605	83	1223	126	118	33
7	30	30	0700	82	1217	119	117	27
8	30	30	0606	81	1205	242	134	23
9	30	30	0612	96	1130	118	142	23
10	30	30	0615	87	1154	114	121	27
11	20	20	0700	65	1200	87	73	26
12	20	20	0742	59	1202	72	93	-
13	30	30	0642	94	1155	114	103	23
14	28	30	0630	85	1201	94	109	24
15	30	30	0632	90	1153	113	119	19
16	30	30	0615	91	1135	108	119	31
17	30	30	0620	93	1150	116	126	23
18	30	30	0620	98 [1/]	1154	118	100	21
19	30	30	0624	86	1155	100	100	40
20	30	30	0619	77	1147	94	122	26
21	30	30	0610	81	1145	105	110	27

1/ Includes 15 minutes spent in repairing a line-break during setting

Table 17a.--Complete catch records, John R. Manning cruise 19, 5-fathom float line gear

Station	Baskets set	Albacore	Bigeye	Yellowfin	Skipjack	Broadbill	Dolphin	Lancet fish	Great blue shark	Others
1	28	-	1	-	-	-	-	-	-	-
2	30	-	1	2	-	-	1	-	2	1 [1/]
3	30	-	1	-	-	-	-	1	-	1 [1/]
4	30	-	-	-	1	-	-	1	1	-
5	30	-	3	-	-	-	-	2	5	1 [2/]
6	30	3	15	-	1	-	-	1	2	-
7	30	-	5	-	-	-	-	1	6	-
8	30	22	-	-	-	-	-	1	-	1 [3/]
9	30	1	-	-	-	-	-	2	3	-
10	30	-	-	-	-	-	-	5	-	-
11	30	-	3	-	-	-	-	8	2	-
12	30	-	2	-	-	-	-	1	2	-
13	30	-	-	-	-	-	-	1	6	-
14	30	-	-	-	-	-	-	2	6	-
15	30	-	-	-	-	-	-	3	1	1 [4/]
16	30	-	-	-	-	-	-	13	1	-
17	30	-	2	-	-	-	-	2	6	-
18	30	-	-	-	-	-	-	9	4	1 [4/]
Total		26	33	2	2	0	1	53	47	6

1/ Sunfish
2/ Bonito shark
3/ Striped marlin
4/ Thresher shark

ble 17b.--Complete catch records, John R. Manning cruise 19, 15-fathom float line gear

tion	Baskets set	Alba-core	Bigeye	Yellow-fin	Skip-jack	Broad-bill	Dol-phin	Lancet fish	Great blue shark	Others
1	30	-	2	-	-	-	1	-	-	2 1/
2	30	-	1	-	-	-	-	-	-	2 2/
3	30	-	-	-	-	-	-	2	1	2 3/
4	30	-	3	1	1	-	-	1	-	-
5	30	-	11	-	-	-	-	5	2	-
6	30	-	15	-	-	-	-	-	2	-
7	30	-	10	-	-	-	-	-	5	1 4/
8	30	20	-	-	-	-	-	-	2	2 5/
9	30	1	-	-	-	-	-	1	5	-
0	30	-	4	-	-	-	-	10	1	-
1	30	-	5	-	1	-	-	4	-	-
2	30	-	4	-	-	-	-	-	-	-
3	30	-	2	-	-	1	-	5	7	-
4	30	-	-	-	-	-	-	5	6	-
5	30	-	-	-	-	-	-	3	4	2 6/
6	30	-	-	-	-	-	-	5	2	2 4/
7	30	-	-	-	-	1	-	3	2	1 4/
8	30	-	-	-	-	-	-	11	5	-
otal		21	57	1	2	2	1	55	44	14

1/ White-tipped shark
2/ Wahoo, white-tipped shark
3/ Bonito shark
4/ Thresher shark
5/ Sunfish, bonito shark
6/ Sting ray, thresher shark

ble 18a.--Complete catch record, John R. Manning cruise 22, 5-fathom float line gear

Station	Baskets set	Alba-core	Bigeye	Spear-fish	Dol-phin	Great blue shark	Mako shark	Lancet fish	Others
1	30	-	2	-	2	1	-	1	-
3	30	-	3	1 1/	1	1	-	4	1 2/
5	30	-	3	-	2	4	-	2	-
7	27	-	-	-	4	4	1	9	1 3/
9	30	-	-	-	1	3	1	3	-
11	30	-	-	2 4/	1	1	-	2	-
13	30	-	-	-	-	-	1	1	-
14	30	-	1	-	-	4	-	-	-
15	30	-	4	1 4/	1	8	-	1	-
17	20	-	-	-	-	6	1	1	-
18	20	-	-	-	-	6	-	-	-
19	30	4	-	-	-	11	-	-	-
21	30	2	-	-	-	8	-	1	-
24	30	-	-	-	-	4	-	-	-
26	30	4	-	-	-	14	-	1	-
28 5/	30 5/	-	-	-	-	20	-	-	-
Total		10	13	4	12	95	4	26	2

1/ Black marlin
2/ White-tipped shark
3/ Wahoo
4/ Striped marlin
5/ Catch of 1 albacore and 3 great blue sharks--type of gear undetermined
6/ Lost 2 baskets of gear

Table 18b.--Complete catch record, John R. Manning cruise 22, 15-fathom float line gear

Station	Baskets set	Albacore	Bigeye	Spearfish	Dolphin	Great blue shark	Mako shark	Lancet fish	Others
1	30	-	3	1 1/	4	2	-	1	-
3	30	-	-	1 2/	2	1	-	2	-
5	30	-	2	-	7	7	-	5	-
7	29	-	2	-	2	3	-	5	-
9	30	-	-	-	1	4	-	4	-
11	30	-	-	-	-	1	2	1	-
13	30	-	-	-	-	3	-	2	-
14	30	-	1	-	-	6	-	1	-
15	30	-	1	-	2	4	-	3	-
17	20	-	-	-	-	8	-	-	-
18	20	1	-	-	-	3	-	6	-
19	30	5	-	-	-	7	-	1	-
21	30	2	-	-	-	4	-	-	-
24	30	3	-	-	-	1	-	-	-
26	29	5	-	-	-	4	-	1	-
28	30	-	-	-	-	17	-	1	-
Total		16	9	2	18	75	2	33	0

1/ Broadbill
2/ Black marlin

Table 19a.--Complete catch record, John R. Manning cruise 23, 5-fathom float line gear

Station	Baskets set	Albacore	Bigeye	Spearfish	Dolphin	Great blue shark	Mako shark	Lancet fish	Others
1	25	-	2	-	-	-	-	-	-
3	30	-	-	-	-	2	-	3	-
5	30	5	-	-	-	5	-	3	1 1/
7	30	4	-	-	-	-	-	5	-
8	30	1	-	-	-	9	-	5	-
9	30	-	-	-	-	3	-	-	-
10	30	-	-	-	1	19	-	-	-
11	20	1	2	-	-	3	-	1	-
12	20	3	-	-	-	3	-	-	-
13	30 2/	-	-	-	-	3	1	2	1 3/
14	28	-	-	-	-	2	-	-	-
15	30	2	-	-	-	1	-	-	-
16	30	-	-	-	-	-	-	2	-
17	30	3	-	-	-	1	-	-	-
18	30	-	1	-	-	3	-	-	-
19	30	2	4	-	-	1	1	-	-
20	30	1	1	-	-	-	-	-	-
21	30	-	-	1 4/	-	6	-	1	-
Total		22	10	1	1	61	2	22	2

1/ Thresher shark
2/ Lost half a basket of gear (6 hooks)
3/ Pelagic sting ray
4/ Shortnosed spearfish

Table 19b.--Complete catch record, John R. Manning cruise 23, 15-fathom float line gear

Station	Baskets set	Albacore	Bigeye	Spearfish	Dolphin	Great blue shark	Mako shark	Lancet fish	Others
1	30	-	3	1 SM	-	-	-	3	-
3	30	-	1	-	-	-	-	2	-
5	30	2	-	-	-	8	-	3	-
7	30	3	-	-	-	1	-	3	-
8	30	6	-	-	-	6	-	2	-
9	30[1/]	-	-	-	-	14	-	1	-
10	30	-	-	-	-	11	-	-	-
11	20	1	-	-	-	2	-	-	-
12	20	2	-	-	-	3	-	-	-
13	30	1	-	-	-	1	-	4	-
14	30	2	-	-	-	2	-	-	-
15	30	3	1	-	-	2	-	-	-
16	30	-	-	-	-	4	-	2	-
17	30	5	1	-	-	1	-	1	-
18	30	-	-	-	-	2	-	2	-
19	30	2	1	-	-	1	-	1	-
20	30	1	-	-	-	1	-	3	-
21	30	-	2	-	-	11	-	1	-
Total		28	9	1	0	70	0	28	0

[1/] Lost half a basket of gear (6 hooks)

Table 20.--Record of tuna tagged during John R. Manning cruises 19, 22 and 23

Species	JRM 19	JRM 22	JRM 23	Total
Albacore	26	18	35	79
Yellowfin	0	1	0	1
Bigeye	41	6	7	54

Table 21.--Summary of dates, locations, and surface water temperatures for troll catches of tuna other than albacore

Species and cruise	Date	Position		Surface temperature
		Latitude	Longitude	°F.
Yellowfin				
Manning 22	10/13/54	Off Midway I.		-
	11/1/54	31°38'N.	176°39'W.	72.6
Gilbert 17	11/7/54	21°23'N.	158°35'W.	79.9
	"	"	"	"
Skipjack				
Manning 22	11/4/54	26°32'N.	173°44'W.	75.0
Gilbert 17	10/28/54	34°33'N.	171°32'W.	68.7
Manning 23	1/26/55	30°23'N.	176°50'W.	65.1
Smith 27	1/18/55	32°00'N.	178°37'W.	63.4
	2/1/55	28°59'N.	179°19'W.	68.0
	2/2/55	32°03'N.	179°35'E.	64.8
	"	"	"	"
	"	"	"	"
	2/8/55	30°04'N.	172°50'W.	62.9
	2/13/55	31°10'N.	166°45'W.	62.3
Little tunny				
Manning 22	10/16/54	Off Midway I.		-

Table 22.--Summary of data on troll captures of miscellaneous species

Cruise	Date	Species	Position		Surface temperature
			Latitude	Longitude	°F.
JRM 22	9/15/54	Dolphin	26°20'N.	159°12'W.	76.9
"	"	"	"	"	"
"	"	"	"	"	"
"	9/23/54	"	39°07'N.	159°50'W.	71.7
"	"	"	"	"	"
"	9/24/54	"	40°44'N.	159°53'W.	69.9
"	"	"	"	"	"
"	11/1/54	Wahoo	31°38'N.	176°39'W.	72.6
"	"	Dolphin	"	"	"
"	11/2/54	"	28°59'N.	177°12'W.	74.0
"	11/4/54	Barracuda	26°52'N.	174°14'W.	76.4
JRM 23	12/6/54	Dolphin	29°32'N.	159°56'W.	70.3
"	"	"	"	"	"
"	"	"	"	"	"
CHG 17	9/19/54	"	25°13'N.	159°53'W.	77.2
"	"	"	"	"	"
"	"	"	"	"	"
"	"	"	"	"	"
"	9/24/54	"	39°25'N.	160°08'W.	70.5
"	11/1/54	"	28°03'N.	179°10'W.	77.0
"	11/2/54	"	27°02'N.	175°27'W.	77.5
"	"	Wahoo	26°53'N.	175°02'W.	77.6
"	11/3/54	Rainbow runner	25°55'N.	172°09'W.	78.5
HMS 27	2/19/55	Dolphin	28°00'N.	159°03'W.	69.6
"	2/20/55	"	26°03'N.	158°45'W.	70.5
"	"	"	"	"	"

Table 23.--Vernacular names of fishes and their commonly accepted scientific names

Albacore, Germo alalunga (Bonnaterre)
Bigeye tuna, Parathunnus sibi (Temminck and Schlegel)
Yellowfin tuna, Neothunnus macropterus (Temminck and Schlegel)
Skipjack, Katsuwonus pelamis (Linnaeus)
Little tunny, Euthynnus affinis (Cantor)
Black marlin, Makaira ampla (Poey)
Striped marlin, Makaira mitsukurii (Jordan and Snyder)
Shortnosed spearfish, Tetrapturus angustirostris (Tanaka)
Broadbill swordfish, Xiphias gladius Linnaeus
Dolphin, Coryphaena hippurus (Linnaeus)
Wahoo, Acanthocybium solandri (Cuvier and Valenciennes)
Barracuda, Sphyraena sp.
Great blue shark, Prionace glauca (Linnaeus)
Bonito shark, Isurus sp.
Thresher shark, Alopias sp.
White-tipped shark, Carcharinus longimanus (Poey)
Lancet fish, Alepisaurus sp.
Rainbow runner, Elagatis bipinnulatus (Quoy and Gaimard)
Sunfish, Mola mola Linnaeus and Ranzania sp.
Pelagic sting ray, Dasyatis atratus (Ishiyama and Okada)

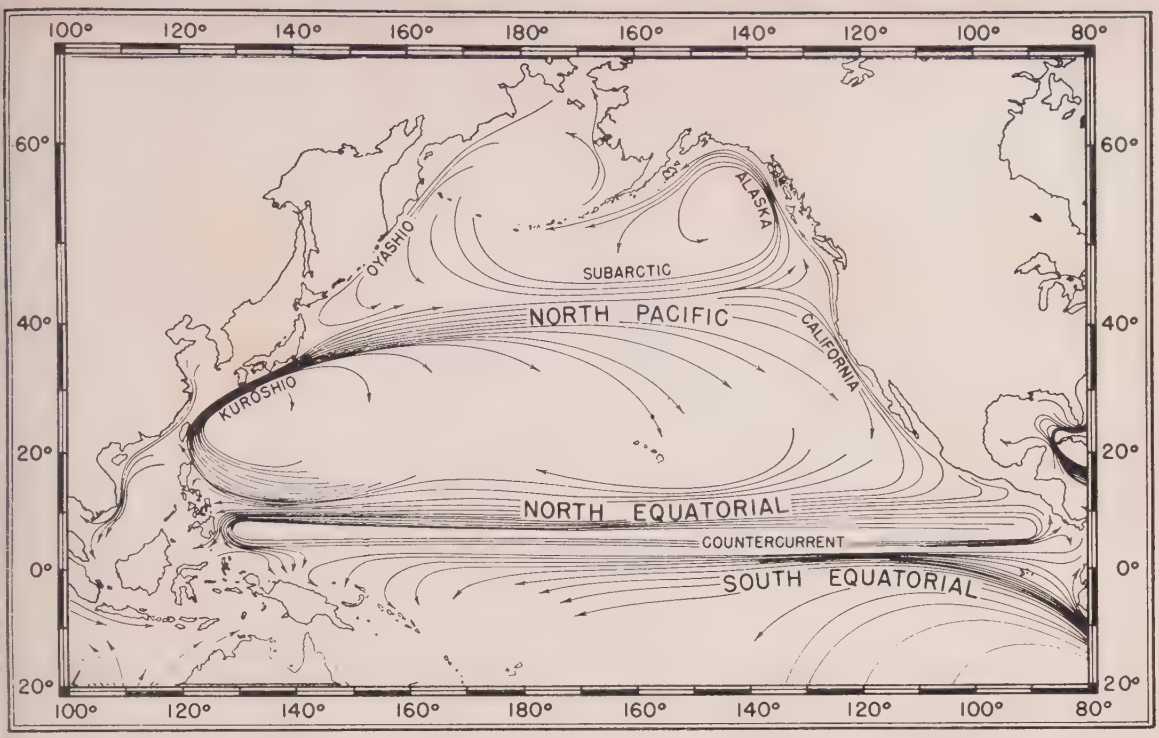

Figure 1.—The major surface currents of the North Pacific Ocean.

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of Albacore

By Albert L. Tester

ober of 1954 Pacific Oceanic Investigations received an al- of funds through the Salton- nedy Act for a study of North Albacore. Since then, we have a large-scale effort to explore an to the north of Hawaii and n Hawaii and the mainland in of potential Albacore fishing s. Realizing that this enormous uld not be easily covered by ganization and taking into ac- the probability that the several nt populations of Albacore in rth Pacific were closely related, l our colleagues in the various h agencies of the Pacific states l a coordinating group known Albacore Steering Committee. mmittee, which is officially rec- d by the Pacific Marine Fish- ommission, contains representa- om the three Pacific states, the of Commercial Fisheries, the Tri-State Commission, and POFI. Its primary purpose is to correlate field work on Albacore so that each of the investigations can make the most efficient use of their available vessels and personnel. In addition, the group meets from time to time to discuss the results of past field work and to lay long-range plans for the future.

In addition to the somewhat formal cooperation described above, the albacore surveys received a spectacular boost this past summer when Fish and Wildlife Service chartered vessels surveying salmon distribution and abundance for the American Section, International North Pacific Fisheries Commission, fished far enough south to show the northern limit of Albacore in mid-ocean, and demonstrated that they could be taken in large numbers in gill nets. It is anticipated that in the future there will be close liaison between Albacore research and the salmon research agencies of the International North Pacific Fisheries Commission.

• *OCEANOGRAPHY*—A schematic version of the surface currents in the North Pacific that are important to the distribution of albacore is shown in the adjoining chart (fig. 1). To the north is the subarctic or Aleutian Current, a sluggish easterly flowing water mass that is comprised largely of cold subarctic water. South of this is the easterly flowing North Pacific Current that is an extension of the warm Kuroshio Current. Proceeding farther south we find the westerly flowing North Equatorial Current, the northern boundary of which lies at approximately 28° N. latitude.

There are two important transition zones in this region. The broad boun-

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dary between the North Equatorial Current and the North Pacific Current is known as the Subtropical Convergence. In the western Pacific the Japanese have a substantial longline fishery extending north of this zone but in the mid-Pacific it has proved unproductive. Lying farther north is the boundary between the North Pacific Current and the Aleutian Current, known as the Polar Front. This zone is characterized by considerably more mixing and turbulence than the Subtropical Convergence and it is in such regions that Albacore occur. In general, in the mid-Pacific their distribution seems to encompass a narrow band of ocean in the vicinity of the Polar Front. This band is displaced to the north in the summer and to the south in the winter.

The hydrographic field studies completed by POFI in mid-ocean should supply definite information on the ecological and physical requirements of the albacore. This may enable research workers and possibly commercial fishermen to predict when and where Albacore will be found. Such knowledge will vastly increase the efficiency of any commercial fishery. In addition, the results of these studies in mid-ocean should provide valuable clues as to why there are variations in the time and place of occurrence of Albacore along the Pacific coast.

● *WINTER DISTRIBUTION* of Albacore in the eastern Pacific insofar as it is known today is succinctly shown in the adjoining figure (fig. 2). Of course there are other occurrences such as sporadic captures off the coast of lower California, but we are here depicting only the occurrence of sizeable numbers of Albacore. It can be readily seen that there is a band extending from 180° eastward to approximately the longitude of the Hawaiian Islands. This band of fish represents an eastward extension of the rather well-defined winter fishing grounds that are regularly exploited by the Japanese to the west of 180°. This zone is of course within fairly easy reach of the Hawaiian Islands and lies rather close to Midway.

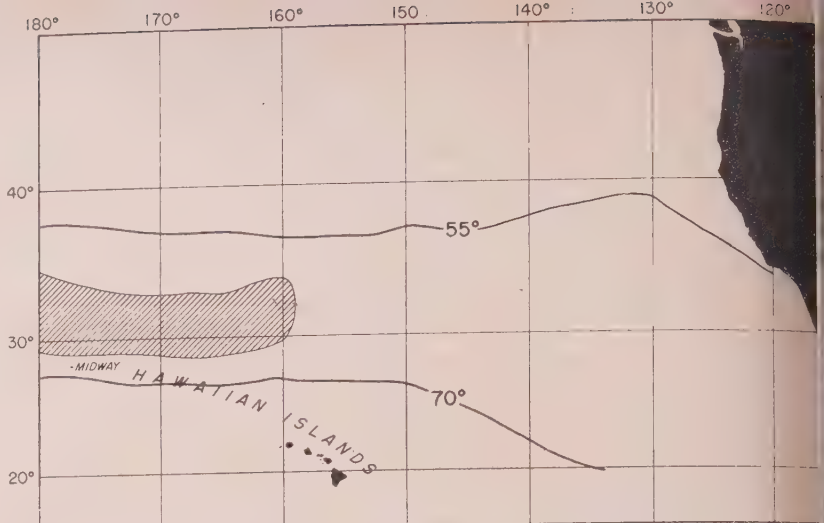

Figure 2. — Winter distribution of Albacore in the eastern North Pacific Ocean, shown ir diagonally shaded.

It is pertinent to note here that during the last two years Japanese commercial fishermen have experienced very low catch rates in their offshore winter grounds. This appears to be reflected in our results; although we have found fish consistently in this zone during the short period of study, our catches have not been strikingly large. Since the Japanese catch rate during the last two years has been only about one-half of that usually encountered in this area, we fully expect that future surveys will indicate higher concentrations of Albacore to the north of Hawaii.

Whether or not this area is p tially capable of supporting a com cial fishery by Americans remain the future. All the elements are ent; operational bases, fish, a method of harvesting the fish. B knowledge of the factors respon for concentrations of albacore wi a long way towards answering question. Of course other impo factors such as weather, whic stormy during the winter season, economic trends will doubtless a development of a fishery.

● *SUMMER DISTRIBUTION*— summer of 1955 saw a tremen amount of effort expended in the seas of the North Pacific. NORP a synoptic oceanographic survey, mounted. This survey involved anese, Canadian, and American ve and provided for the first time com hensive coverage of the entire N Pacific, north of 30° N., and sh be invaluable in furthering our un standing of the distributions of sal and tuna in the area. In addition, POFI vessel and one California v were in the field surveying alba and several vessels were studying distribution of salmon to the nort

The oceanographic results wil be available for some time but fishing results have been summa on the adjoining chart (fig. 3). we see a composite picture resu from the gill net catches of alb by the salmon gill netters *Paragon Mitkof*,* indicated by squares; the catches of the *Hugh M. Smith*, cated by triangles; and the troll ca of the *John R. Manning*, indicate solid dots. Also shown on this are the tracks of the two POFI

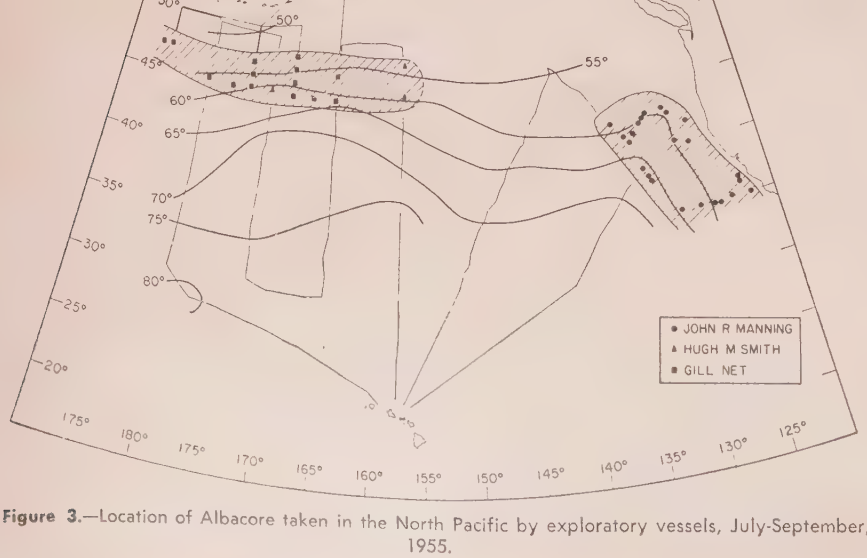

Figure 3.—Location of Albacore taken in the North Pacific by exploratory vessels, July-September, 1955.

*Data supplied by courtesy of Atkinson, Chief, Pacific Salmon I gations, U. S. Fish and Wildlife S Seattle, Washington.

he surface temperature iso-
These summer surveys show
rly that there was an exten-
of Albacore in the north
acific between 45° and 50°
eding east, there appears to
h a gap in the occurrence of
until approximately 135° W.

East of this longitude, the
found Albacore widely dis-
off the coast of Oregon and
in a broad band which lay
) miles offshore in the north
ached the coast in the south.
hern extremity of the band
ourse, fished by the Califor-
ercial fishery.

later in the year, that is, dur-
mber and early October, PO-
another vessel, the *Charles*
rt, to fish the area to the
of Hawaii. This time sig-
numbers of albacore were
the area which had formed
the distribution during Au-
h were caught with longlines,
ear and gill net, the last two
s giving the most promising

DVANCES—As a result of
er and fall work, two impor-
nces have been made. *First*
ow know that there are large
of albacore to the north of
onstituting a hitherto un-
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ven more exciting, is the fact
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is not possible to state with
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dings. General surveys such
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possible and usually show
than the presence or ab-
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ne whether or not the popu-
abundant enough to sup-
ffshore or mid-ocean fishery
mmer or fall. We hope to
b an effort in the future after
obtained more precise infor-
n the most probable location

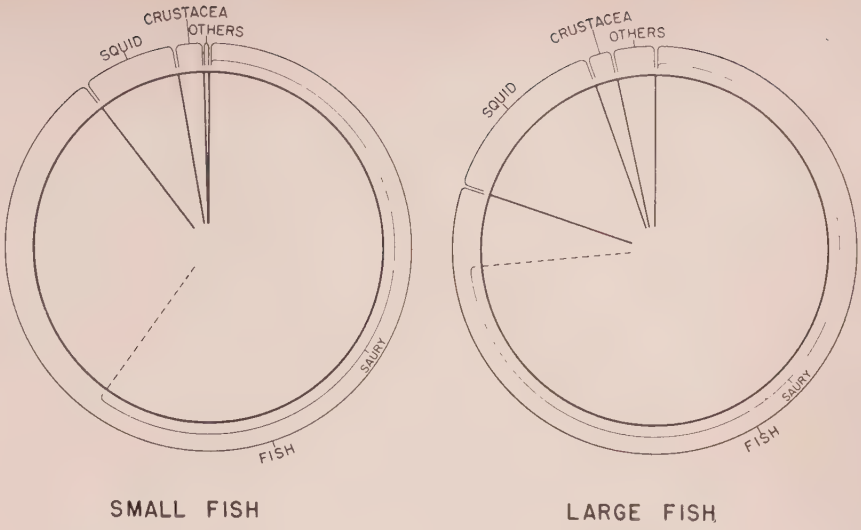


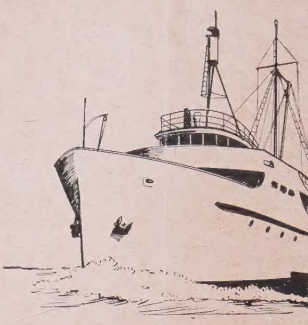
Figure 4.—Food of north central Pacific Albacore.

of concentrations of fish and, particularly, after we have more clearly delineated the environmental factors that restrict the Albacore to narrow segments of the ocean. The latter is probably the most important objective since it will never be possible to predict when and where to catch Albacore unless we understand the reasons for their occurrence in particular places at particular times. Until this is accomplished fisheries must remain on a hit-or-miss basis.

• *FOOD FACTORS* — In addition to studies on the circulation of the water and the distribution of Albacore, a number of supporting programs have been initiated. POFI is conducting an intensive study of plankton organisms in the North Pacific and preliminary results indicate that the occurrence of Albacore is closely related to the occurrence of certain types of readily identifiable plankton organisms. This work should provide another tool in understanding the where and why of Albacore. Other problems must, of course, be explored before we can say that we understand a species of fish and its fishery. Life history work on Albacore is being currently carried out, studies centering around the spawning problem, the growth rate problem, and the food requirements of the Albacore.

An indication of the preliminary results from the food studies is given in the adjacent figure (fig. 4). It is quite evident that the saury, a moderate sized forage fish found widely distributed over the central Pacific, is exceedingly important to the albacore. This suggests that in the process of understanding Albacore we must also understand saury, their distribution, their life history, and the types of water they prefer to live in.

• *IN CONCLUSION* a few general observations may be made. Delineating and predicting Albacore occurrence is a vast undertaking which under present circumstances can be accomplished only by cooperative effort of the several research agencies of the Pacific states and the Federal Government. Observations must be taken over large distances of the North Pacific to obtain an understanding of the offshore distribution, as well as the inshore distribution, both of which are related to each other, and to variation in oceanographic conditions. Coverage less extensive than we are obtaining now will mean that establishing an Albacore fishery based upon an understanding of the conditions which control their distribution will be seriously delayed.



Recent Equatorial TUNA RESEARCH

nted from Pan American Fisherman, March, 1956

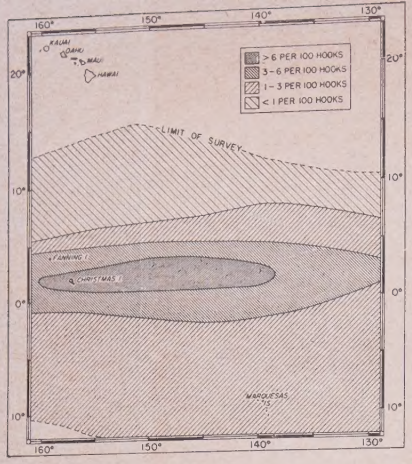


Figure 1—Abundance of yellowfin tuna in the central Pacific.

Recent Equatorial TUNA RESEARCH

By ALBERT L. TESTER

Director,
Pacific Oceanic Fishery Investigations,
U.S. Fish and Wildlife Service

As is well known to many of our readers, the Pacific Oceanic Fishery Investigations (POFI) was established in 1949 to evaluate the aquatic resources of the central and western Pacific Ocean. As envisioned, the program involved much more than simply conducting superficial surveys of the abundance of fishes; rather, the plan was to study first the oceanic circulation of the area in order to locate regions of the ocean that were favorable to the existence of concentrations of commercially valuable species.

For several reasons, the first area selected for study was the equatorial region south of Hawaii. In this area, available oceanographic information suggested there was upwelling, or enrichment, of the surface waters at and near the Equator. Our initial research confirmed this and, further, indicated that this enriched water moved northward to about 5° N. latitude. It was reasoned that in this general zone between the Equator and 5° N. latitude there would be unusually favorable circumstances for the existence of tuna.

Initial attempts to survey the tuna met with rather sporadic success until the Japanese longline was used. This gear, fished systematically from north to south across the equatorial zone, revealed that there was an unusually dense concentration of large, deep-swimming yellowfin occupying the area shown on the chart (Figure 1).

It is possible that this band of yellowfin could have been located more quickly by eliminating the study of the environment, but this seems doubtful in view of the immense area of the equatorial Pacific and, furthermore, there would have been no way of knowing whether the band of tuna was a permanent concentration or merely a transient population. In contrast, our integrated studies of the circulation, the productivity, the food supply, and the tuna give us confidence that the resource is a reasonably stable feature of the ocean.

The first attempts to fish commercially in the equatorial area followed the extensive exploratory work by POFI which showed that the resource was indeed present during most periods of the year and that the catch rates, on the average, were high enough to support American fishermen. Another factor in the timing of the initial exploitation in early 1954 was the very favorable status of the tuna market insofar as Amer can fishermen were concerned.

The first attempt to fish in the ar was made by two vessels from t west coast, the *North American* a the *Alrita*. These vessels, using Ame ican crewmen, were rigged for lon line fishing and together fished a aggregate of about 120 days in t general vicinity of Christmas Isla during the period February to Apr 1954. They were aided by POFI this initial venture to new fishi grounds to the extent of partly d fraying the cost of tooling up for new type of fishing.

Considering the numerous hand caps, such as using new gear a fishing in strange grounds, these ve sels did remarkably well. Their cat rates (shown in Figure 2) were hig enough to be profitable but not hig

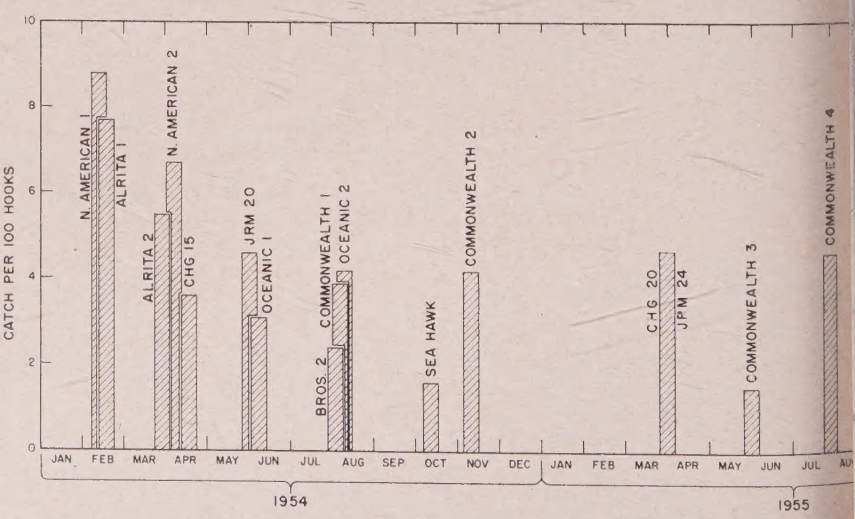
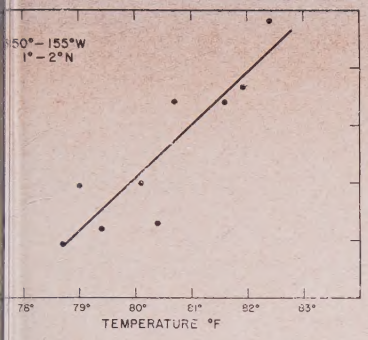


Figure 2—Catch rates in the vicinity of Christmas Island. The first commercial expeditio appear on the extreme left.



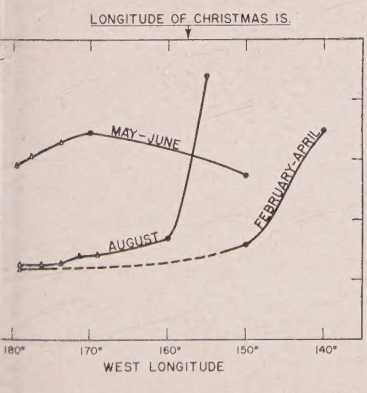
3—Yellowfin catch and temperature surface layer of water (1950-1953).

h to make the venture spectac- successful.

lowing this initial attempt, were several other less preten- ventures into the Line Islands y. As shown in the figure oppo- hese were not as successful as rliest trials. Reasons for this lie in the use of new and rela- untried gear, but also it is evident that there was a real ae in the abundance of yellow- the Line Islands area during atter half of 1954, a decline persisted into 1955.

first glance it might appear that experiences are simply a rep- of the frequently observed n of good fishing when a new d is first utilized, followed by sequent decline. This argument ot seem reasonable. The area ed is vast and the number of aken by the first commercial es must surely have been insig- t in comparison to the total ation.

ddition, we now have evidence d to show that the decline in bundance after 1954 was re- o a change in the environment Line Islands area. In fact, the r fishing might have been pre-



5—Yellowfin catch 1953, 5°N.-5°S., ng, the east-west shifts in abundance.

dicted had our knowledge then been up to the present level.

Briefly, our explanation for this poor fishing follows the logic used in first locating this new fishing ground. We have noted that the newly upwelled water found at the Equator is considerably cooler than the water to the north and south and generally contains few fish. As the water moves northward it "matures," a condition reflected in an increase in temperature, and the following biological succession takes place: the nutrient salts or fertilizers stimulate the growth of minute aquatic plants which, in turn, support an augmented supply of tiny plankton animals and these, in turn, furnish food for tuna forage.

some time ago, and while it was maturing tuna forage developed, and tuna concentrated in the area. Apparently these variations are the result of variations in the equatorial winds; strong winds drive the water rapidly northward to the sinking of convergence zone and moderate winds allow the tuna forage to develop before the water sinks.

Following this very promising lead, we examined the oceanographic data from our station at Christmas Island and found that much the same story could be derived from this more recent information. The relationship between ocean water temperature and tuna fishing during the 1954 period, when fishing was very concentrated and the catch rates quite

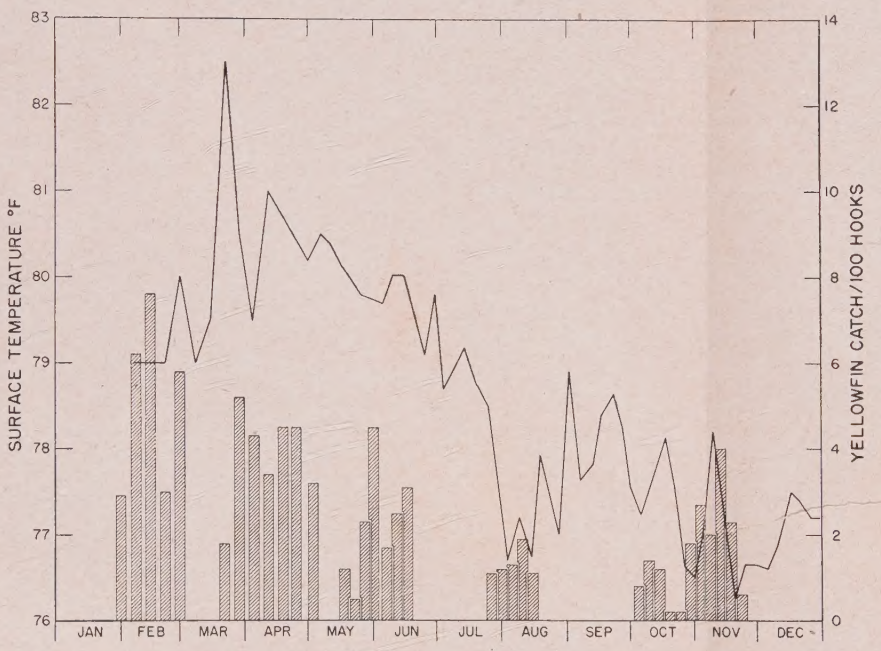


Figure 4—Water temperatures and yellowfin catch rates in the vicinity of Christmas Island, 1954.

The tuna, of course, may be expected to congregate in areas possessing an unusually large supply of food, and to move out of these areas if they suffer a decline in the food supply. According to our theory, a decline in food supply would be indicated by a decrease in temperature.

A recently completed critical examination of experimental fishing results from 1950 to 1953 shows that the success of fishing in the Line Islands area was closely related to the temperature of the water (Figure 3). The very cool water, 78° to 79° F. in temperature, has been recently fertilized and has not yet developed a supply of tuna food.

The warmer water was enriched

reliable, is depicted in Figure 4. It is very clear from this that the decline in fishing success in the vicinity of Christmas Island was paralleled by decline in the water temperature in that area.

Thus it appears that we have a plausible explanation of the poor fishing subsequent to the early part of 1954—an explanation which is related to changes in the equatorial circulation. As in all probability these changes are related in turn to changes in the weather, it is conceivable that more detailed knowledge of the weather may lead eventually to long-range forecasts of fishing success in the equatorial region.

(Continued on back page)

Recent Equatorial Tuna Research

(Continued from previous page)

We have been discussing fishing conditions in the general vicinity of Christmas Island; however, the resource is not tied to Christmas Island or to any other land mass and is, in fact, a fluid resource, moving from place to place in the equatorial system and apparently concentrating where food supplies are greatest. Figure 5 shows our results for 1953, plotted on a latitudinal axis. When fishing is poor at one longitude it may be very much better either to the east or west.

For instance, examine the February-April curve. Fishing was very poor in the vicinity of 180° and rather poor around 150° W., the general longitude near Christmas Island. However, at this same time quite good fishing was found on 140° W., some 600 miles to the east.

Here again, this same set of observations seems susceptible to the temperature analysis we discussed above, for, at the time that the surveys were made, the water was considerably warmer at 140° W. than at 150° W. This is reasonable proof of our theories because, usually, the water is cooler at 140° W. than at 150° W. During the period of this survey the trend was reversed and the warmer water was found to the east and, sure enough, the yellowfin tuna were also found to the east.

Our program in the equatorial area should be continued in the future, for American industry will probably expand in this direction when the economic situation is more favorable than at the present time. We could aid this expansion by two service projects; first, development work to mechanize the longline gear so that it will be a more economical tool in the hands of Americans, and second, electro-sonic fish detection so that we may learn more about the distribution of the tuna and perhaps pinpoint their location. If this could be done it could make it unnecessary to set the longline gear blind.

Over and above this, our "routine" survey program is drawing to a close and our seagoing effort in this area will be restricted to special cruises designed to test the hypotheses, or theories, which have been discussed above. One of the special projects involves following a given body of water as it moves north and west away from the Equator and actually measuring the changes in the nutrient salts, the plankton, the forage fish, and the tuna as the water warms up and passes through the cycle we have described above.

Another program, as yet in the planning stage, is a simultaneous oceanographic survey of the entire equatorial region. This will involve a number of vessels—American, Japanese, and possibly French—and will be designed to cover the equatorial Pacific from the eastern end, where the American fishery exists, to the Philippines. This multiple ship cruise will give invaluable insight into the circulation as a whole and will also serve to tie together the many less extensive surveys that have been conducted in the past, both by POFI and by other agencies operating to the east. ★